Chapter 3
Risk

Chapter Contents

This chapter addresses the exposures and associated risks that may result from using the substitute blanket washes. Section 3.1 contains information on environmental releases. Potential releases to air, and land and water are discussed for each blanket wash. Section 3.2 examines potential occupational exposures. The dermal and inhalation exposures that can occur as a result of working with a blanket wash are presented. Section 3.3 addresses exposures for the general population (i.e., people not working in the print shop), and includes information on human exposures to blanket wash chemicals released to both air and surface water. In all three sections, the methodologies and models used for estimating releases and exposures are described along with the associated assumptions and uncertainties. Section 3.4 moves from exposures to the risks and concerns associated with such exposures. Descriptions of how risk characterizations are made and the types of risks examined (such as carcinogenic, chronic and developmental), are followed by discussions of the risks assigned to the environmental, occupational and general population exposures discussed earlier in the chapter. In Section 3.5, methods of reducing worker risk are discussed. Topics such as employee training, proper handling of chemicals, and use of personal safety equipment and equipment safeguards are reviewed.

3.1 ENVIRONMENTAL RELEASE ESTIMATES

Estimated environmental releases associated with lithography blanket wash chemicals and the methodology, assumptions and uncertainties associated with the release calculations are discussed below. Releases to air result from volatilization of volatile blanket wash constituents during fluid (blanket wash) transfers and from waste rags used to wipe blanket wash liquid off of the blankets. Releases to water result primarily from the laundering of dirty reusable rags. Releases to land result from the disposal of non-reusable rags.

<u>Methodology - Environmental Releases</u>

The material balance approach was used to calculate releases from lithography blanket washes. Figure 3-1 decribes the overall material balance:

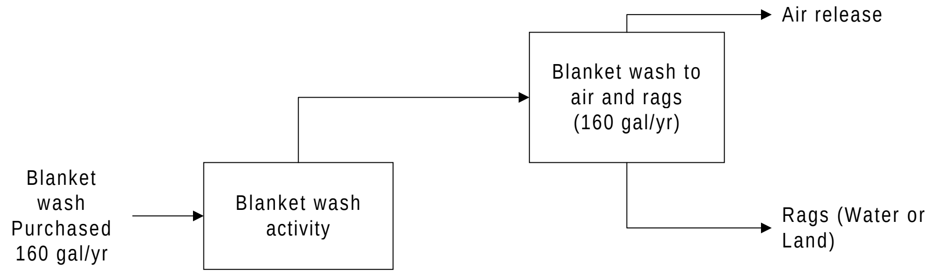

Figure 3-1. Material Balance

General facility assumptions were developed specifically for the scenarios of this assessment. These assumptions were developed by EPA in conjunction with Gary Jones of the Graphic Arts Technical Foundation (GATF) and were released for review during the ECB/GATF Environmental Affairs Conference held in Oakbrook, Illinois in March 1994. Those assumptions were as follows:

Assumption	Value
Number of presses per facility	1-19"x 26"
Number of units per press	4
Number of times each blanket is washed per day	10 (40 total for the press)[1]
Number of hours per operating day	8
Number of operating days per year	250
Average amount of wash used per blanket	2 oz.
Area of 1 blanket	3.4 ft^2
Amount of blanket wash used per year	160 gallons

[1] Industry commentators noted during a later review of draft results that washing the blanket 10 times per day may be high for this type of facility. If this assumption is high, using 10 blanket washes per day may overestimate exposures.

An average of 160 gallons of blanket wash is assumed to be used per year per facility (rounded to two significant figures). The 160 gallons is either released to air or is left on the rag for disposal or laundering.

A typical shop may either use reusable rags, which are laundered, or dispose of rags as municipal solid waste. Volatile chemicals (>10^{-3} mm Hg vapor pressure) were assumed to be released to air whether reusable or disposable rags are used. Non-volatile chemicals ($\leq 10^{-3}$ mm

Hg vapor pressure[a]) were assumed to remain on the rags. Chemicals remaining on reusable rags were released to water and chemicals remaining on disposal rags were released to land. **The model does not take into account the releases of ink constituents that are being removed in the blanket wash.**

The material balance calculations are conducted as follows for each formulation:

- Calculate the average density of the formulation using the normalized weight percent; (see sample calculation)
- Multiply the average density by the volume released (160 gallons) to get the total mass of blanket wash released;
- Multiply the total mass by the weight percentage of each chemical in the formulation to determine individual chemical masses;
- If the vapor pressure of a chemical constituent is > 10^{-3} mm Hg, then the chemical is assumed to be released to air; and
- If the vapor pressure is $\leq 10^{-3}$ mm Hg, then the chemical will not volatilize and is assumed to be released to water or land. Releases to water occur when the rags are laundered, and to land when they are disposed of.

<u>Sample Calculation</u>

Example Formulation	Density (g/cm^3)	Weight Percent	Vapor Pressure (mmHg)
Ethoxylated nonylphenol	0.8	42.9%	$<10^{-6}$
Solvent naphtha, heavy	0.87	33.3%	0.5
Propylene glycol monobutyl ether	0.89	19.0%	<0.98
Tetrapotassium pyrophosphate	2.33	4.8%	$<10^{-6}$

[a] *An industry reviewer commented that the 10^{-3} mm Hg cutoff may be low. This figure was developed by EPA's Health and Environmental Effects Division for the New Chemicals Review Program to be protective of human health. Below 10^{-3} mm Hg no further concern for inhalation risks is warranted. Above 10^{-3} mm Hg there may or may not be concerns.*

In this example:

- The average density of the blanket wash is 0.867 g/cm

$$\sum_{I=1}^{n} \frac{\text{weight fraction}_i}{\text{density}_i} = \sum_{i=1}^{n} \frac{\dfrac{g_i}{g_{formulation}}}{\dfrac{g_i}{cm^3_i}} = \sum_{i=1}^{n} \frac{cm^3_i}{g_{formulation}}$$

$$= \frac{cm^3_{formulation}}{g_{formulation}}$$

The reciprocal of this value is the average density of the blanket wash in g/cm^{3}.

In this example, we have

$$\frac{1}{\left[\frac{0.429}{0.8} + \frac{0.333}{0.87} + \frac{0.19}{0.89} + \frac{0.48}{2.33}\right]} = 0.867 \text{ g/cm}^3$$

- Using the average density, the total mass of blanket wash per year is calculated to be 525,196 g/yr.

- The mass of each chemical component is calculated, the vapor pressure is evaluated to determine the release route and the following release rates are calculated:

Example Formulation	Release to Air* (g/site/sec)	Release to Water or Land (kg/site/yr)
Ethoxylated nonylphenol	0	225.3
Solvent Naphtha, heavy	0.024	0
Propylene glycol monobutyl ether	0.014	0
Tetrapotassium pyrophosphate	0	25.2
Total:	0.038	251

* The time units for releases to air are calculated using 250 days per year and 8 hours per day. The environmental releases for each blanket wash formulation are provided in Table 3-1.

Assumptions - Environmental Releases

The material balance used in this report assumes that releases to air equal the total air release of chemicals from the following:

- Volatilization of blanket wash formulation constituents from blankets during cleaning;

- Emissions from transfer operations; and
- Volatilization of blanket wash constituents from dirty rags.

As described on page 3-2, the following assumptions and sources of information were used in the material balance model:

- Chemicals with a vapor pressure $\leq 10^{-3}$ mm Hg will not volatilize;
- Chemicals that do not volatilize will remain on the cleaning rags.
- The general facility assumptions listed above.

Uncertainties - Environmental Releases

Determining environmental releases associated with lithography blanket washes requires making assumptions about the cleaning process, the workplace environment and waste management practices. Uncertainties about the amounts of releases to the environment stem from the estimated total released per year (160 gallons). This total will vary in actual printing facilities based on:

- type of blanket wash used;
- amount of blanket wash applied;
- amount of unused blanket wash disposed;
- compliance with waste management procedures;
- equipment operating time;
- temperature conditions (ambient and solvent);
- chemical properties.

Table 3-1. Environmental Releases: Lithographic Blanket Washes

Form. Number	Formulation**	Environmental Releases: Air (g/sec)	Environmental Releases: Water or Land (kg/yr)
1	Fatty acid derivatives	0.062	0
	Alkoxylated alcohols	0.014	0
3	Hydrocarbons, petroleum distillates	0.021	0
	Fatty acid derivatives	0	152
	Hydrocarbons, aromatic	0.025	0
	Alkyl benzene sulfonates	0	38
4	Terpenes	0.059	0
	Ethoxylated nonylphenol	0	77
5	Water	N/A	N/A
	Hydrocarbons, aromatic	0.021	0
	Ethylene glycol ethers	0.010	0
	Ethoxylated nonylphenol	0	50
	Alkyl benzene sulfonates	0	30
	Alkoxylated alcohols	0	15
	Alkali/salts	0	5
6	Fatty acid derivatives	0	329
	Hydrocarbons, petroleum distillates	0.018	0
	Hydrocarbons, aromatic	0.006	0
	Alkyl benzene sulfonates	0	25

Form. Number	Formulation**	Environmental Releases	
		Air (g/sec)	Water or Land (kg/yr)
7	Terpenes	0.071	0
	Ethoxylated nonylphenol	0	15
	Alkoxylated alcohols	0	15
8	Water	N/A	N/A
	Hydrocarbons, aromatic	0.018	0
	Propylene glycol ethers	0.012	0
	Alkyl benzene sulfonates	0	91
	Ethoxylated nonylphenol	0	43
	Alkoxylated alcohols	0	13
	Alkali/salts	0	4
9	Fatty acid derivatives	0	405
	Water	N/A	N/A
	Ethoxylated nonylphenol	0	15
10	Fatty acid derivatives	0	140
	Water	N/A	N/A
11	Fatty acid derivatives	0	249
	Hydrocarbons, petroleum distillates	0.028	0
	Hydrocarbons, aromatic	0.005	0
	Alkyl benzene sulfonates	0	23
12	Hydrocarbons, petroleum distillates	0.033	0
	Water	N/A	N/A
14	Fatty acid derivatives	0	54
	Propylene glycol ethers	0.008	0
	Water	N/A	N/A
16	Terpenes	0.075	0
17	Ethoxylated nonylphenol	0	11
	Glycols	0.002	0
	Fatty acid derivatives	0	5
	Alkali/salts	0	3
	Water	N/A	N/A
18	Fatty acid derivatives	0	225
	Hydrocarbons, petroleum distillates	0.022	0
	Hydrocarbons, aromatic	0.005	0
	Dibasic esters	0.009	0
	Esters/lactones	0.003	0
	Alkyl benzene sulfonates	0	23
19	Fatty acid derivatives	0	182
	Propylene glycol ethers	0.051	0
	Water	N/A	N/A
20	Water	N/A	N/A
	Hydrocarbons, petroleum distillates	0.010	0
	Hydrocarbons, aromatic	0.007	0
	Alkyl benzene sulfonates	0	25

Form. Number	Formulation**	Environmental Releases Air (g/sec)	Water or Land (kg/yr)
21	Hydrocarbons, aromatic	0.014	0
	Hydrocarbons, petroleum distillates	0.021	0
	Fatty acid derivatives	0	257
22	Fatty acid derivatives	0	288
	Hydrocarbons, aromatic	0.017	0
	Water	N/A	N/A
23	Terpenes	0.034	0
	Nitrogen heterocyclics	0.021	0
	Alkoxylated alcohols	0.021	0
	Water	N/A	N/A
24	Terpenes	0.013	0
	Ethylene glycol ethers	0.003	0
	Ethoxylated nonylphenol	0	23
	Alkyl benzene sulfonates	0	35
	Alkali/salts	0	23
	Water	N/A	N/A
25	Terpenes	0.072	0
	Esters/lactones	0.003	0
26	Fatty acid derivatives	0	604
	Esters/lactones	0	256
27	Terpenes	0.12	0
28	Hydrocarbons, petroleum distillates	0.059	0
29	Fatty acid derivatives	0	533
30	Hydrocarbons, aromatic	0.049	0
	Propylene glycol ethers	0.008	0
	Water	N/A	N/A
31	Hydrocarbons, aromatic	0.010	0
	Hydrocarbons, petroleum distillates	0.058	0
32	Hydrocarbons, petroleum distillates	0.066	0
33	Hydrocarbons, petroleum distillates	0.018	0
	Hydrocarbons, aromatic	0.018	0
	Propylene glycol ethers	0.004	0
	Water	N/A	N/A
34	Water	N/A	N/A
	Terpenes	0.015	0
	Hydrocarbons, petroleum distillates	0.012	0
	Alkoxylated alcohols	0	42
	Fatty acid derivatives	0	42
35	Hydrocarbons, petroleum distillates	0.010	0
	Hydrocarbons, aromatic	0.058	0
36	Fatty acid derivatives	0	376
	Hydrocarbons, petroleum distillates	0.013	0
	Hydrocarbons, aromatic	0.007	0
	Propylene glycol ethers	0.003	0

Form. Number	Formulation**	Environmental Releases Air (g/sec)	Water or Land (kg/yr)
37	Water Hydrocarbons, petroleum distillates Hydrocarbons, aromatic	N/A 0.034 0.003	N/A 0 0
38	Hydrocarbons, petroleum distillates Alkoxylated alcohols Fatty acid derivatives	0.048 0.012 0	0 0 0
39	Water Hydrocarbons, petroleum distillates Propylene glycol ethers Alkanolamine Ethylene glycol ethers	N/A 0.015 0.008 0 0.004	N/A 0 0 17 0
40	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates Fatty acid derivatives Ethoxylated nonylphenol	0.009 0.012 0 0	0 0 346 22

**Formulation compositions were adjusted to equal 100 percent.
N/A - Not applicable

3.2 OCCUPATIONAL EXPOSURE ESTIMATES

Inhalation and dermal exposure associated with lithography blanket wash chemicals and the methodology, assumptions and uncertainties associated with the estimates are discussed below. The scenario described below was modelled to assess inhalation and dermal exposures for workers at these shops. Table 3-2 presents the inhalation and dermal exposures for lithographic blanket washes.

Table 3-2. Inhalation and Dermal Exposures: Lithographic Blanket Washes

Form. Number	Formulation[1]	Inhalation Exposure[2] (mg/day)	Dermal Exposure[3] (mg/day)
1	Fatty acid derivatives Alkoxylated alcohols	0.23 0.026	1,100-3,300 200-590
3	Hydrocarbons, petroleum distillates Fatty acid derivatives Hydrocarbons, aromatic Alkyl benzene sulfonates	7.2 negligible 14.8 negligible	730-2,200 390-1,200 121-360 61-180
4	Terpenes Ethoxylated nonylphenol	74 negligible	1,100-3,400 159-480

Form. Number	Formulation[1]	Inhalation Exposure[2] (mg/day)	Dermal Exposure[3] (mg/day)
5	Water Hydrocarbons, petroleum distillates Ethylene glycol ethers Ethoxylated nonylphenol Alkyl benzene sulfonates Alkoxylated alcohols Alkali/ salts	N/A 0.54 0.010 negligible negligible negligible negligible	N/A 340-1,000 170-510 100-300 54-162 27-81 7-20
6	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	negligible 5.4 0.82 negligible	910-2,700 290-880 58-180 37-110
7	Terpenes Ethoxylated nonylphenol Alkoxylated alcohols	2.42 negligible negligible	1,225-3,750 37-110 37-110
8	Water Hydrocarbons, aromatic Propylene glycol ethers Alkyl benzene sulfonate Ethoxylated nonylphenol Alkoxylated alcohols Alkali/ salts	N/A 0.52 0.67 negligible negligible negligible negligible	N/A 290-870 180-530 196-580 87-260 23-70 6-17
9	Fatty acid derivatives Water Ethoxylated nonylphenol	negligible N/A negligible	990-3,000 N/A 25-76
10	Fatty acid derivatives Water	negligible N/A	270-820 N/A
11	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	negligible 7.5 0.63 negligible	670-2,000 540-1,600 54-160 34-100
12	Hydrocarbons, petroleum distillates Water	1.68 N/A	650-1,960 N/A
14	Fatty acids derivatives Propylene glycol ethers Water	negligible 0.009 N/A	98-290 98-290 N/A
16	Terpenes	2.55	1300-4000
17	Ethoxylated nonylphenol Propylene glycol Fatty acid derivatives Alkali/ salts Water	negligible 0.008 negligible negligible N/A	23-68 23-68 11-34 6-17 N/A

Form. Number	Formulation[1]	Inhalation Exposure[2] (mg/day)	Dermal Exposure[3] (mg/day)
18	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Dibasic esters Esters/lactones Alkyl benzene sulfonates	negligible 5.8 0.62 0.194 0.68 negligible	640-1,900 430-1,300 57-170 108-330 36-110 36-110
19	Fatty acid derivatives Propylene glycol ethers Water	negligible 0.021 N/A	100-290 260-780 N/A
20	Water Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	N/A 0.36 0.12 negligible	N/A 130-400 100-300 33-100
21	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates Fatty acid derivatives	2.2 7.1 negligible	260-780 390-1,200 650-2,000
22	Fatty acid derivatives Hydrocarbons, aromatic Water	negligible 0.73 N/A	720-2,100 260-780 N/A
23	Terpenes Nitrogen heterocyclics Alkoxylated alcohols Water	0.83 0.037 0.001 N/A	92-280 57-170 57-170 N/A
24	Terpenes Ethylene glycol ethers Ethoxylated nonylphenol Alkyl benzene sulfonates Alkali/salts Water	2.3 0.002 negligible negligible negligible N/A	210-620 52-160 52-160 78-230 52-160 N/A
25	Terpenes Esters/lactones	2.11 2.4	1,248-3,840 52-160
26	Fatty acid derivatives Esters/lactones	negligible negligible	1,219-3,758 45-135
27	Terpenes	4.69	1,300-3,900
28	Hydrocarbons, petroleum distillates	240	1,300-3,900
29	Fatty acid derivatives	negligible	1,300-3,900
30	Hydrocarbons, aromatic Propylene glycol ethers Water	1.9 0.026 N/A	910-2,700 130-390 N/A
31	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates	0.88 11	200-590 1,100-3,300
32	Hydrocarbons, petroleum distillates	24	1,300-3,900

Form. Number	Formulation[1]	Inhalation Exposure[2] (mg/day)	Dermal Exposure[3] (mg/day)
33	Hydrocarbons, petroleum distillates	0.93	310-920
	Hydrocarbons, aromatic	0.44	310-920
	Propylene glycol ethers	0.068	34-100
	Water	N/A	N/A
34	Water	N/A	N/A
	Terpenes	3.3	230-680
	Hydrocarbons, petroleum distillates	0.56	170-510
	Alkoxylated alcohols	negligible	85-250
	Fatty acid derivatives	negligible	85-250
35	Hydrocarbons, petroleum distillates	11	200-590
	Hydrocarbons, aromatic	0.88	1,100-3,300
36	Fatty acid derivatives	negligible	900-2,700
	Hydrocarbons, petroleum distillates	4.1	230-680
	Hydrocarbons, aromatic	1.0	110-340
	Propylene glycol ethers	0.37	57-170
37	Water	N/A	N/A
	Hydrocarbons, petroleum distillates	1.67	625-1,840
	Hydrocarbons, aromatic	0.064	32-97
38	Hydrocarbons, petroleum distillates	10	980-2,900
	Alkoxylated alcohols	0.022	200-590
	Fatty acid derivatives	negligible	130-390
39	Water	N/A	N/A
	Hydrocarbons, petroleum distillates	0.60	220-670
	Propylene glycol ethers	0.31	110-330
	Alkanolamines	negligible	30-89
	Ethylene glycol ethers	0.003	52-160
40	Hydrocarbons, aromatic	1.4	130-380
	Hydrocarbons, petroleum distillates	4.0	190-570
	Fatty acid derivatives	negligible	950-2,800
	Ethoxylated nonylphenol	negligible	38-110

[1] Formulation compositions were adjusted to equal 100 percent.
[2] The inhalation exposures are based on a "what if" scenario.
[3] The dermal exposures are bounding estimates and assume that no gloves or barrier creams are used by the workers.
[4] In situations where the chemical is corrosive (e.g., sodium hydroxide), dermal exposure to workers using the appropriate gloves is zero.

Negligible - Inhalation exposures to chemicals with vapor pressures <10 $^{-3}$mmHg were assumed negligible.

N/A - Not applicable

Scenario

Based on the general facility assumptions listed in Section 3.1, a press operator is assumed to wash 40 blankets per shift. Each wash lasts two minutes. The worker squirts 2 ounces of wash solution onto a rag using a squirt bottle. The blanket is wiped with the wet rag and then wiped again with a dry rag. All rags are disposed of in closed storage containers.

Inhalation exposures result from the volatilization of chemicals from the blanket during washing and from the rags used to wash the blanket. Unvolatilized materials that remain on the rags are assumed to be disposed of as solid waste or to be removed at a laundry facility. Inhalation exposures to vapors from opening the containers storing the disposed rags are assumed to be negligible. Inhalation exposures to chemicals with a vapor pressure $< 10^{-3}$ mm Hg are also assumed to be negligible.

Dermal exposures result from contact with the blanket wash solution during blanket washing activities. Dermal exposures are estimated based on type of operations and wash formulation concentrations.

Methodology - Inhalation Exposures

Inhalation exposures were estimated from the scenario described above using a material balance inhalation exposure model[b]. The inhalation exposure assessment falls under the "what if" category (see uncertainties section).

The material balance model assumes that the amount of a chemical in a room equals the amount of chemical generated in the room minus the amount of chemical leaving the room. The model is valid for estimating the displacement of vapors from containers and for estimating the volatilization of liquids from open surfaces. The assumptions used in this model include:

- Incoming room air is contaminant-free;
- Vapor generation and ventilation rates are constant over time;
- Room air and ventilation air mix ideally;
- Raoult's Law is valid (i.e., regarding the volatilization and interaction of vapors);
- Ideal gas law applies (i.e., regarding the interaction of vapors); and
- "Typical case" ventilation parameters are valid (actual ventilation conditions are unknown).

The inhalation exposure model[1] estimates the evaporation of chemicals from open surfaces, such as the surface of a blanket, using the following equations:

[b] *Source: U.S. Environmental Protection Agency, Chemical Engineering Branch (CEB) Manual for the Preparation of Engineering Assessments, (February 28, 1991), p. 4-1 through 4-39.*

$$G_i = \frac{0.02MX_iP_i}{RT}\sqrt{\frac{D_{ab}v_z}{\pi z}} \qquad (1)$$

where:

G_i	=	Volatilization rate of subsurface i, $g/m^2\cdot sec$
M	=	Molecular weight, g/mol
P_i*	=	Vapor pressure of pure substance i, mm Hg
X_i	=	Mole fraction of substance i in solution, dimensionless
R	=	Gas constant, 0.0624 mm $Hg\cdot m^3/mol\cdot K$
T	=	Temperature, K
D_{ab}	=	Diffusivity, cm^2/sec
v_z	=	Air velocity, m/sec
z	=	Distance along contaminated surface, m

The air velocity v_z is assumed to be 100 feet per minute (ft/min). Since the diffusivity (D_{ab}) is not available for many of the chemicals used in blanket washing formulations, the following equation is used to estimate diffusivity:

$$D_{ab} = \frac{4.09 \times 10^{-5}\, T^{1.9}\, (1/29 + 1/M)^{0.5}\, M^{-0.33}}{P_t} \qquad (2)$$

D_{ab}	=	Diffusivity, cm^2/sec
T	=	Temperature, K
M	=	Molecular weight, g/mol
P_t	=	Total pressure, atm

Equation 2 is based on kinetic theory and generally gives values of D_{ab} that agree closely with experimental data. The volatilization rate (G_i), calculated in Equations 1 and 2 above, is used in the following mass balance equation to calculate the airborne concentration of a substance in the breathing zone:

$$C_v = \frac{1.7 \times 10^5\ TGiA}{MQk} \qquad (3)$$

where:

C_v	=	Airborne concentration, ppm
T	=	Ambient temperature, K
G_i	=	Volatilization rate of substance i, $g/m^2\cdot sec$
M	=	Molecular weight, g/mol
A	=	Area of surface, m^2
Q	=	Ventilation rate, ft^3/min
k	=	Mixing factor, dimensionless

The mixing factor (k) accounts for slow and incomplete mixing of ventilation air with room air. The CEB Manual sets this factor at 0.5 for a typical case and at 0.1 for a worst case.

The CEB Manual commonly uses ventilation rates (Q) of 500 to 3,500 ft^3/min. An effective ventilation rate of 1,500 ft^3/min was used in the model. This rate is equal to the mixing factor of 0.5 multiplied by the "typical case" ventilation rate (3,000 ft^3/min). The value of C_v from Equation 3 is converted to mass/volume units using the following equation:

$$C_m = C_v \frac{M}{V_m} \qquad (4)$$

where:

C_m	=	Airborne concentration, mg/m^3
C_v	=	Airborne concentration, ppm
M	=	Molecular weight, g/mol
V_m	=	Molar volume of an ideal gas, L/mol

At 25°C, V_m has a value of 24.45 L/mol. Since a worker can be assumed to breathe about 1.25 m^3 of air per hour, an inhalation exposure can be computed once C_m has been determined. Equations 3 and 4 can be combined to yield the following equation, given the "typical case" choice of ventilation parameters:

$$I = 0.48GAt \qquad (5)$$

where:

I	=	Total amount of substance inhaled, mg/day
G	=	Vapor generation rate, g/m^2·sec
A	=	Area of surface, m^2
t	=	Duration of exposure, sec/day

The following variables for the lithography model shop are based on the Chemical Engineering Branch Manual (EPA, 1991)[11]

- v_z = 100 ft/min (air velocity)
- T = 298 K (temperature)
- Q = 3,000 ft^3/min (ventilation rate)
- k = 0.5 (mixing factor, dimensionless)
- $P_i = X_i \cdot P_i^*$ (Raoult's Law)

The following variables are based on the assumptions presented on page 3-2. These assumptions were reviewed during the ECB/GATF Environmental Affairs Conference held in Oakbrook, Illinois in March, 1994.

- z = 26 in (distance along contaminated surface)
- A = 494 in^2 (area of surface)
- The average time to wash one blanket is 2 minutes.

- The average number of blankets washed per shift is 40.
- The average worker is exposed to wash vapors 80 minutes per day (t = 4,800 seconds per day).
- Dilutions with water are accounted for in formulation compositions.
- Adjusted values were used for the formula compositions because they did not always sum to 100%.

Sample Calculation - Inhalation Exposures

Example Formulation (compositions are percent by weight):

Range	Adjusted*	
35-45%	42.9%	Ethoxylated nonylphenol
25-35%	33.3%	Solvent naphtha (petroleum), heavy aromatic
15-20%	19.0%	Propylene glycol monobutyl ether
0-5%	4.8%	Tetrapotassium pyrophosphate
75-105%	100%	Total

* In cases where the maximum range values of the chemical compositions did not add up to 100%, the values were adjusted to 100%.

The diffusivity is calculated using Equation 2, as follows:

$$D_{ab} = \frac{4.09 \times 10^{-5}\, T^{1.9} (1/29 + 1/M)^{0.5}\, M^{-0.33}}{P_t}$$

The following values are obtained from the Basic Chemical Data Report for solvent naphtha (petroleum), heavy aromatic:

T = 298 K
M = 128 g/mol
P_t = 1 atm

$D_{ab} = 0.085\ cm^2/sec$

Using the above value for diffusivity, the volatilization rate can be calculated using Equation 1, as follows:

$$G_i = \frac{0.02MX_iP_i}{RT}\sqrt{\frac{D_{ab}v_z}{\pi z}}$$

where:

M	=	128 g/mol
P_{*i}	=	0.5 mm Hg
X_i	=	0.5346 (mole fraction)
R	=	0.0624 mm Hg·m^3/mol·K
T	=	298 K
D_{ab}	=	0.0852 cm^2/sec
v_z	=	100 ft/min = 0.508 m/sec
z	=	26 in = 0.6604 m

$$\boxed{G_i = 0.0053\ \text{g/m}^2\cdot\text{sec}}$$

Using this value for G_i, the exposure may be calculated using Equation 5, as follows:

$$I = 0.48GAt$$

where:

G	=	0.0053 g/m^2·sec
A	=	494 in^2 = 0.3187 m^2
t	=	80 min = 4,800 sec/day

$$\boxed{I = 3.9\ \text{mg/day}}$$

Using the same method for each chemical in the Example Formulation, the following results are obtained:

Chemical	Inhalation Rate
Ethoxylated nonylphenol	Negligible
Solvent naphtha (petroleum), heavy aromatic	3.9 mg/day
Propylene glycol monobutyl ether	4.3 mg/day
Tetrapotassium pyrophosphate	Negligible

<u>Methodology - Dermal Exposures</u>

Dermal exposure is caused by contact with a material. For the blanket press operators, contact with the material includes touching the damp rags and manually applying the rags to the blanket to remove ink. Routine contact with two hands was modeled for the dermal exposure assessment.

The dermal contact model[1] was used to calculate dermal exposure estimates for blanket washing activities by adjusting the concentration of the chemical in the mixture. This model provides bounding estimates and assumes that no gloves or barrier creams are used by the workers. In situations where the chemical is corrosive (e.g., sodium hydroxide), dermal exposure to workers using the appropriate gloves is negligible. Also, for other chemicals, if the appropriate gloves are worn exposure to workers will be negligible.

Assumptions used in the dermal model[1] include:

- The concentrations of the chemicals in the mixture are constant (i.e., no evaporation) throughout the time of absorption;
- No dermal protection, administrative, work practice, or other controls are used to limit dermal exposure;
- The surface area of two hands is 1300 cm^2;
- The amount that is actually absorbed is not determined;
- The quantity remaining on the hand is 1-3 mg/cm^2; and
- A single contact with the chemical results in exposure for a complete work day. That is, the duration of exposure is estimated at 1-4 hours or longer, but it is assumed the worker washes up at meal time, and if the duration is reported for a full day, the potential dose should total only the estimate for a single contact.

<u>Sample Calculation - Dermal Exposures</u>

Using the Example Formulation:

Ethoxylated nonylphenol = 42.9% (Adjusted weight %)

The dermal exposure to blanket washes for routine dermal contact (2 hands) is 1,300 to 3,900 mg/day[1]. (e.g., 1-3 mg/cm^2 x 1300 cm^2/day)

The dermal exposure to ethoxylated nonylphenol is 42.9% of the total blanket wash exposure, or 560 to 1,700 mg/day.

Using the same method for each chemical in the Example Formulation, the following results are obtained:

Chemical	Dermal Exposure
Ethoxylated nonylphenol	560 to 1,700 mg/day
Solvent naphtha (petroleum), heavy aromatic	430 to 1,300 mg/day
Propylene glycol monobutyl ether	250 to 740 mg/day
Tetrapotassium pyrophosphate	62 to 190 mg/day

Uncertainties - Occupational Exposures

Any determination of the occupational exposure levels associated with blanket washing activities requires making assumptions about the washing processes, workplace environment, health and safety practices, and waste management practices.

EPA has published Guidelines for Exposure Assessment in the *Federal Register*. These guidelines provide the basic terminology and principles by which the Agency conducts exposure assessments. If the exposure assessment methodology allows an assessor to in some way quantify the spectrum of exposure, the assessor should assess typical exposures, as well as high-end exposures or bounding exposures. **Typical** exposures refer to exposures of a typical person to a particular substance. **High-end** exposures refer to exposures of a person exposed to amounts of a substance higher than exposures received by 90 percent of the people (or ecological species of interest) exposed to the substance. **Bounding** exposures are judgments assuming that no one will be exposed to amounts of substance higher than the calculated amount. However, in many cases, only a picture of what the exposure would be under a given set of circumstances, without a characterization of the probability of these circumstances, can be calculated. These pictures are called **"What if"** scenarios,[c] and they do not try to judge where on the exposure scale the estimate actually falls. The inhalation exposure assessments calculated for the blanket press operators fall under the "what if" category and the dermal exposure assessments are bounding exposures.

Although the blanket washing process is relatively straightforward, occupational exposure levels will differ in shop environments because of many variables, including:

- Volatility of blanket wash used;
- Amount of blanket wash applied;
- Application of chemicals to blanket and rags;
- Use of personal protective equipment and safety procedures;
- Blanket washing time;
- Ventilation conditions and shop layout;
- Number of blankets cleaned;
- Temperature conditions (ambient and solvent);
- Average size of blankets; and
- Number of presses per facility.

[c] *A "what-if scenario" is a scenario developed to assess potential exposure under a set of hypothetical conditions or under a set of conditions for which actual exposure parameter data are incomplete or nonexistent. The calculated exposures are not intended to provide information about how likely the combination of exposure parameter values might be in the actual population or approximately how many, if any, persons might actually be subjected to the calculated exposure.*

3.3 GENERAL POPULATION EXPOSURE ESTIMATES

The purpose of this general population exposure assessment is to determine non-occupational exposures to lithography blanket wash chemicals. This determination addresses contact by people who are not directly involved in the lithography process. People who live near a printing facility may breathe air containing small amounts of vapors from evaporation of products at the printing facility. Residues from the blanket wash products enter the environment when facilities, either printer facilities or laundries washing the rags, discharge the products down the drain, either to a publicly-owned treatment works (POTW) or through a septic system. Once the chemicals enter surface water, they may travel downstream and enter a drinking water facility. People could then be exposed by drinking this water. People may also drink well water that contains contaminants that have migrated from a landfill where wastes, especially rags and empty containers, are disposed. For each of these contact routes, the amount of exposure depends on several factors: distance from the facility, the actual routes of contact (such as drinking, breathing, touching), the length of time the chemical has been in the environment, and the way that the chemical moves through the environment. The potential exposures also depend on environmental conditions, including the weather and the volume of water in the stream or river which receives the facility's discharges.

The general population exposure assessment should not be compared to the occupational health standards to determine if an exposure is reasonable or not. Many occupational standards are based on technological feasibility, rather than ideal risk reduction. Furthermore, measuring internal facility contaminant levels may not be sufficient to determine significant general population exposure. Certain types of controls simply move the chemical from inside the plant to the outdoors, creating higher concentrations outside the facility than inside the facility. Some pathways of exposure, such as the drinking water path, do not exist for workers. It is also important to note that some chemicals may have a more significant impact on a specific segment of the general population, such as children, than on a typical worker.

Chapter 2 contains summaries for the fate of all of the chemicals identified as being used in blanket wash products. The fate of the chemical in the environment is how we refer to the breakdown (transformation) and mobility of the chemical through air, water, and land. Chemical fate differs for release through a waste water treatment facility as opposed to an air release or a landfill release. Definitions of the terms used to describe the fate are also included in Chapter 2. For this assessment, the percent removal during wastewater treatment and the half-life of the chemical in air are the primary elements taken from the fate assessment. The other properties and processes listed were used to derive or estimate these values.

This assessment addresses two perspectives: local and regional. The local point of view considers a single facility in normal operation. It will have certain releases that affect a specific area and specific local population. Since information is not available for each lithography facility, a "model facility" approach is used to calculate typical releases and environmental concentrations. This approach will not allow us to specify the number of people around the facility because the population varies considerably depending on the location of the printing facility. The regional perspective provides insight into the overall impact of releases from all of the printing facilities for the general population. While one facility may not be releasing very much of any given chemical, the cumulative effect of all of the printers in an area could be serious. The regional perspective was modeled using facilities located in a single city, Denver, Colorado, to provide an example of cumulative exposures.

This exposure assessment should be used in conjunction with the health assessment to provide a balanced picture of risk. The specific effects of a chemical, such as acute (short-term) effects or chronic (long-term) effects, determine what period(s) of exposure to consider. For long-term (chronic) effects, such as carcinogenicity, it is most helpful to have average, or typical, exposures, since the effect depends on the cumulative exposure. For acute effects, which can include things such as eye irritation, a peak exposure estimate would be more helpful. This can then be compared with levels at which the chemical is known to cause immediate health problems. Since the information which would allow peak exposures to be calculated is not available, average concentrations are calculated in this assessment.

Uncertainty

Estimating exposures is a science where many pieces are approximated, leading to some uncertainty in the results of the estimates. In this assessment we used a model facility approach, where the model facility was not an actual printing facility which exists. In our modeling, we have fixed certain data points to specific values. Although we have previously used weather data specifically for San Bernardino, this does not mean that the concentration results have no meaning for a different location. Many locations would have roughly the same concentration results as San Bernardino, and no locations would have concentrations of less than one tenth of the results for San Bernardino. Often, data parameters are fixed because we know what selecting this combination of values does to the relative value of the risk. The building height, temperature and the exit velocity in air modeling are examples of these types of parameters. We have set them to maximize the average concentrations close to the facility. Some people would call this a worst case, or a bounding estimate. In actuality, since we have presented a scenario for modeling, but do not know how often those exposure levels (or, potential doses) actually exist, the exposure estimates should be labeled a “What if.” These What if estimates answer a question similar to “What happens if the building is always three meters tall, the air escaping has little exit velocity, and is ambient temperature?” It is a very good basis for comparing risk between formulations.

Overview by Media

The following sections provide an overview of general population exposures that may occur via air, surface water, septic systems, and landfills.

Air

Local Exposure: Releases to air result from evaporation of chemicals during the blanket wash process. Activities include allowing blankets to dry, using shop towels during blanket cleaning, or opening the containers that hold the blanket wash. These vapors are then carried by and mixed with outside air. The resulting air concentration will depend on weather conditions. Stagnant conditions will not move vapors away quickly, so local concentrations of the chemical will be higher than the concentrations farther from the plant. Under windy conditions, the vapors will be carried away faster, reducing the local concentrations. The number of people may increase or decrease with distance from the facility. The location of the printing facility will also influence the exposure. If the location is known, the exposure assessor will use a computer program to determine weather patterns. The number of people around a known facility will be determined by using census data.

For our model facility, we assume a building height of three meters, and a width of 10 meters. This is a building approximately the size of a one-car garage. We then pick sample weather conditions to determine what the air concentration of a chemical will be at a set distance from the printing facility. San Bernardino is used because the weather conditions there will result in the highest average concentrations around the facility of any of the approximately 500 weather stations in the United States. The average concentrations around San Bernardino are within an order of magnitude (power of ten) of concentrations expected anywhere else in the country. If the San Bernardino average concentration were estimated as 10 $\mu g/m^3$, then the average concentration anywhere in the country would be greater than 1 $\mu g/m^3$.

The model used is called Industrial Source Complex Long Term (ISCLT). It was developed as a regulatory model by the EPA's Office of Air and Radiation. The Office of Pollution Prevention and Toxics uses an implementation of ISCLT in the Graphical Exposure Modeling System (GEMS). Appendix B contains an example of an input file for this model. Except for items identified, the parameters entered are the regulatory defaults. The model will calculate more than one chemical at a time and is run in urban 3 mode. Also entered into the model is the decay rate of the chemical. To convert from the half-life of the chemical (given in the fate summaries in Chapter 2) to the decay rate in inverse seconds, divide 0.693 (the natural log of 2) by the half-life in seconds.

The amount released, given in this document in units of grams per second, is calculated in grams per second per meter squared. Since our model facility is 10 meters per side, or 100 meters square, the release is divided by 100.

In order to obtain the concentration at 100 meters, a special polar grid was entered. The ring distances specified were 100 meters, 200 meters, 300 meters, 400 meters, 500 meters, 600 meters, 700 meters, 800 meters, 900 meters and a kilometer. The air dispersion model calculates the average air concentrations of the chemical vapors in the specified sectors. The sectors are defined by the rings and the compass points, forming an arc-shaped area. There were three calculations per sector. The compass point with the highest concentration at 100 meters was then used to determine exposure. The location was at 90°, that is, east.

From the concentration in the air, the amount with which an individual may actually come in contact can be calculated by knowing the breathing rate. A moderately active adult breathes 20 m^3 per day. The formula for an annual dose is:

$$\text{Annual Dose} = \text{Concentration x Daily Inhalation Rate x Days per year}$$

where the concentration is in $\mu g/m^3$, and the breathing rate is in cubic meters per day. The potential dose normalized for body mass calculated per day for the entire lifetime, is called the Lifetime Average Daily Dose or LADD (Table 3-3). The formula for this dose rate is:

$$\text{LADD} = \frac{\text{Concentration x Daily Inhalation Rate x 0.001 mg/}\mu\text{g}}{\text{Average Body Weight}}$$

The average body weight used in this assessment is 70 kg (an average adult). Since there is no ratio for the percentage of days spent breathing air containing evaporated blanket wash chemicals, this calculation assumes that a person will be breathing this concentration every day of their life.

Uncertainty

Within our scenario, there are specific parameters which affect final concentrations and therefore final exposures more than others. Since we are using the estimates for comparison, the single most important factor is the amount of the substance released per formulation. This is true for both air and water.

Air releases have many factors which fold into the behavior of the chemical. A stronger fan will increase the number of people outside the facility who come in contact the chemical, because the chemical will stay concentrated farther. A higher temperature will cause the chemical to rise in the air. The relative differences between these things is not as significant to the final concentration as is the amount released.

Table 3-3. Single Facility 100 Meter Air Concentrations and Residential Population Potential Dose Rates[1]

Form. Number	Chemical Components	100 Meter Concentration ($\mu g/m^3$)	Annual Pot. Dose (mg/year)	LADD (mg/kg/day)
1	Fatty acid derivatives Alkoxylated alcohols	10 3	80 20	3×10^{-3} 8×10^{-4}
3	Hydrocarbons, petroleum distillates Fatty acid derivatives Hydrocarbons, aromatic Alkyl benzene sulfonates	4 4.2	30 28.7	1×10^{-3} 1.29×10^{-3}
4	Terpenes Ethoxylated nonylphenol	10	70	3×10^{-3}
5	Water Hydrocarbons, aromatic Ethylene glycol ethers Ethoxylated nonylphenol Alkyl benzene sulfonates Alkoxylated alcohols Alkali/salts	 4 2	 30 10	 1×10^{-3} 5×10^{-4}
6	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	 3 1	 20 7	 9×10^{-4} 3×10^{-4}
7	Terpenes Ethoxylated nonylphenol Alkoxylated alcohols	12	95	4.5×10^{-3}
8	Water Hydrocarbons, aromatic Propylene glycol ethers Alkyl benzene sulfonates Ethoxylated nonylphenol Alkoxylated alcohols Alkali/salts	 3 2	 20 20	 9×10^{-4} 6×10^{-4}
9	Fatty acid derivatives Water Ethoxylated nonylphenol			
10	Fatty acid derivatives Water			
11	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	 5 9×10^{-1}	 40 7	 1×10^{-3} 3×10^{-4}
12	Hydrocarbons, petroleum distillates	5.9	47	1.3×10^{-3}
14	Fatty acid derivatives Propylene glycol ethers	 1	 9	 4×10^{-4}
16	Terpenes	12.5	100	4.6×10^{-3}

Form. Number	Chemical Components	100 Meter Concentration ($\mu g/m^3$)	Annual Pot. Dose (mg/year)	LADD (mg/kg/day)
17	Ethoxylated nonylphenol			
	Glycols	5×10^{-1}	4	1×10^{-4}
	Fatty acid derivatives			
	Alkali/salts			
	Water			
18	Fatty acid derivatives			
	Hydrocarbons, petroleum distillates	4	30	1×10^{-3}
	Hydrocarbons, aromatic	9×10^{-1}	7	3×10^{-4}
	Dibasic esters	1.8	12	6×10^{-4}
	Esters/lactones	6×10^{-1}	4	2×10^{-4}
	Alkyl benzene sulfonates			
19	Fatty acid derivatives			
	Propylene glycol ethers	9	70	3×10^{-3}
20	Hydrocarbons, petroleum distillates	2	10	5×10^{-4}
	Hydrocarbons, aromatic	1	9	3×10^{-4}
	Alkyl benzene sulfonates			
21	Hydrocarbons, aromatic	3	20	7×10^{-4}
	Hydrocarbons, petroleum distillates	4	30	1×10^{-3}
	Fatty acid derivatives			
22	Fatty acid derivatives			
	Hydrocarbons, aromatic	3	20	9×10^{-4}
23	Terpenes	6	40	2×10^{-3}
	Nitrogen heterocyclics	4	30	1×10^{-3}
	Alkoxylated alcohols	4	30	1×10^{-3}
24	Terpenes	2	20	7×10^{-4}
	Ethylene glycol ethers	6×10^{-1}	4	2×10^{-4}
	Ethoxylated nonylphenol			
	Alkyl benzene sulfonates			
	Alkali/salts			
25	Terpenes	12.3	93	4.4×10^{-3}
	Esters/lactones	6×10^{-1}	4	2×10^{-4}
26	Fatty acid derivatives			
	Esters/lactones			
27	Terpenes	21	140	6.3×10^{-3}
28	Hydrocarbons, petroleum distillates	10	70	3×10^{-3}
29	Fatty acid derivatives			
30	Hydrocarbons, aromatic	9	60	2×10^{-3}
	Propylene glycol ethers	1	10	4×10^{-4}
31	Hydrocarbons, aromatic	2	10	5×10^{-4}
	Hydrocarbons, petroleum distillates	10	70	3×10^{-3}
32	Hydrocarbons, petroleum distillates	10	90	3×10^{-3}
33	Hydrocarbons, petroleum distillates	3	20	9×10^{-4}
	Hydrocarbons, aromatic	3	20	9×10^{-4}
	Propylene glycol ethers	6×10^{-1}	4	2×10^{-4}

Form. Number	Chemical Components	100 Meter Concentration ($\mu g/m^3$)	Annual Pot. Dose (mg/year)	LADD (mg/kg/day)
34	Water			
	Terpenes	3	20	7×10^{-4}
	Hydrocarbons, petroleum distillates	2	20	6×10^{-4}
	Alkoxylated alcohols			
	Fatty acid derivatives			
35	Hydrocarbons, petroleum distillates	2	10	5×10^{-4}
	Hydrocarbons, aromatic	10	70	3×10^{-3}
36	Fatty acid derivatives			
	Hydrocarbons, petroleum distillates	2	20	7×10^{-4}
	Hydrocarbons, aromatic	1	8	3×10^{-4}
	Propylene glycol ethers	6×10^{-1}	4	2×10^{-4}
37	Water			
	Hydrocarbons, petroleum distillates	12	80	4×10^{-3}
	Hydrocarbons, aromatic	5	40	1×10^{-3}
38	Hydrocarbons, petroleum distillates	8	60	2×10^{-3}
	Alkoxylated alcohols	2	20	6×10^{-4}
	Fatty acid derivatives			
39	Water			
	Hydrocarbons, petroleum distillates	3	20	7×10^{-4}
	Propylene glycol ethers	1	10	4×10^{-4}
	Alkanolamines			
	Ethylene glycol ethers	7×10^{-1}	5	2×10^{-4}
40	Hydrocarbons, aromatic	2	10	5×10^{-4}
	Hydrocarbons, petroleum distillates	2	20	6×10^{-4}
	Fatty acid derivatives			
	Ethoxylated nonylphenol			

[1] A blank space in the table indicates that there were no air releases for the chemical because the chemical would not evaporate readily.

Regional Exposure: For the second approach, the overall general population exposure picture resulting from multiple printing facilities was sought. The total residential population exposed to blanket wash chemicals was not available, since the locations of all the lithography facilities across the country are not known. Instead, a single city was used and all known facilities within that city were modeled to provide a general idea of exposures that might result from cumulative releases. Denver was chosen as an example city (Table 3-4). Within the city limits of Denver, Dun and Bradstreet report 235 lithographers. The example assumes that all of the lithographers in Denver use each blanket wash formulation at the same time. The average concentration for the city of Denver is then calculated, using local weather data. The 1990 population for the city of Denver is approximately 470,000.

In this case, the model used is BOXMOD, also implemented in the Graphical Exposure Modeling System. It uses a parameter called the Time Constant to account for chemical degradation. The time constant is the inverse of the rate of decay used for the ISCLT model. This is also the half-life in air divided by 0.693. The other parameter needed to run the model is the size of the area being modeled. Denver is 277.13 square kilometers, or 16.65 kilometers on a side. An example of a BOXMOD run is located in Appendix B.

Table 3-4. Denver Average Air Concentrations and Residential Population Potential Dose Rates[1]

Form. Number	Chemical Components	100 Meter Concentration ($\mu g/m^3$)	Annual Pot. Dose (mg/year)	LADD (mg/kg/day)
1	Fatty acid derivatives Alkoxylated alcohols	1 4×10^{-1}	9 3	3×10^{-4} 1×10^{-4}
3	Hydrocarbons, petroleum distillates Fatty acid derivatives Hydrocarbons, aromatic Alkyl benzene sulfonates	6×10^{-1} 6.5×10^{-1}	4 5	2×10^{-4} 1.45×10^{-4}
4	Terpenes Ethoxylated nonylphenol	1	8	3×10^{-4}
5	Water Hydrocarbons, aromatic Ethylene glycol ethers Ethoxylated nonylphenol Alkyl benzene sulfonates Alkoxylated alcohols Alkali/salts	 6×10^{-1} 2×10^{-1}	 4 1	 2×10^{-4} 6×10^{-5}
6	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	 5×10^{-1} 2×10^{-1}	 4 1	 1×10^{-4} 6×10^{-5}
7	Terpenes Ethoxylated nonylphenol Alkoxylated alcohols	1.72	12.6	4.56×10^{-4}
8	Water Hydrocarbons, aromatic Propylene glycol ethers Alkyl benzene sulfonates Ethoxylated nonylphenol Alkoxylated alcohols Alkali/salts	 5×10^{-1} 3×10^{-1}	 4 2	 1×10^{-4} 9×10^{-5}
9	Fatty acid derivatives Water Ethoxylated nonylphenol			
10	Fatty acid derivatives Water			
11	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	 8×10^{-1} 1×10^{-1}	 6 7×10^{-1}	 2×10^{-4} 3×10^{-5}
12	Hydrocarbons, petroleum distillates	9×10^{-1}	6.7	2.3×10^{-4}
14	Fatty acid derivatives Propylene glycol ethers	 2×10^{-1}	 1	 6×10^{-5}
16	Terpenes	1.89	13.3	5.2×10^{-4}

Form. Number	Chemical Components	100 Meter Concentration (µg/m^3)	Annual Pot. Dose (mg/year)	LADD (mg/kg/day)
17	Ethoxylated nonylphenol Glycols Fatty acid derivatives Alkali/salts Water	 4×10^{-2}	 3×10^{-1}	 1×10^{-5}
18	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Dibasic esters Esters/lactones Alkyl benzene sulfonates	 6×10^{-1} 1×10^{-1} 2.6×10^{-1} 8×10^{-2}	 4 7×10^{-1} 2 6×10^{-1}	 2×10^{-4} 3×10^{-5} 8×10^{-5} 2×10^{-5}
19	Fatty acid derivatives Propylene glycol ethers	 1	 9	 4×10^{-4}
20	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	3×10^{-1} 2×10^{-1}	2 1	9×10^{-5} 6×10^{-5}
21	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates Fatty acid derivatives	4×10^{-1} 6×10^{-1}	3 4	1×10^{-4} 2×10^{-4}
22	Fatty acid derivatives Hydrocarbons, aromatic	 5×10^{-1}	 4	 1×10^{-4}
23	Terpenes Nitrogen heterocyclics Alkoxylated alcohols	8×10^{-1} 5×10^{-1} 6×10^{-1}	6 4 4	2×10^{-4} 1×10^{-4} 2×10^{-4}
24	Terpenes Ethylene glycol ethers Ethoxylated nonylphenol Alkyl benzene sulfonates Alkali/salts	3×10^{-1} 8×10^{-2}	2 6×10^{-1}	9×10^{-5} 2×10^{-5}
25	Terpenes Esters/lactones	1.63 8×10^{-2}	12.4 6×10^{-1}	4.59×10^{-4} 2×10^{-5}
26	Fatty acid derivatives Esters/lactones			
27	Terpenes	3	23	7.9×10^{-4}
28	Hydrocarbons, petroleum distillates	2	10	5×10^{-4}
29	Fatty acid derivatives			
30	Hydrocarbons, aromatic Propylene glycol ethers	1 2×10^{-1}	9 1	4×10^{-4} 6×10^{-5}
31	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates	3×10^{-1} 2	2 10	9×10^{-5} 6×10^{-4}
32	Hydrocarbons, petroleum distillates	2	10	5×10^{-4}
33	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Propylene glycol ethers	5×10^{-1} 5×10^{-1} 8×10^{-2}	4 4 6×10^{-1}	1×10^{-4} 1×10^{-4} 2×10^{-5}

Form. Number	Chemical Components	100 Meter Concentration (µg/m³)	Annual Pot. Dose (mg/year)	LADD (mg/kg/day)
34	Water Terpenes Hydrocarbons, petroleum distillates Alkoxylated alcohols Fatty acid derivatives	 3×10^{-1} 3×10^{-1}	 2 2	 9×10^{-5} 9×10^{-5}
35	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic	3×10^{-1} 2	2 10	9×10^{-5} 5×10^{-4}
36	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Propylene glycol ethers	 4×10^{-1} 2×10^{-1} 8×10^{-2}	 3 1 6×10^{-1}	 1×10^{-4} 6×10^{-5} 2×10^{-5}
37	Water Hydrocarbons, petroleum distillates Hydrocarbons, aromatic	 1.8 8×10^{-1}	 14 6	 6×10^{-4} 2×10^{-4}
38	Hydrocarbons, petroleum distillates Alkoxylated alcohols Fatty acid derivatives	1 3×10^{-1}	9 2	4×10^{-4} 9×10^{-5}
39	Water Hydrocarbons, petroleum distillates Propylene glycol ethers Alkanolamines Ethylene glycol ethers	 4×10^{-1} 2×10^{-1} 9×10^{-2}	 3 1 7×10^{-1}	 1×10^{-4} 6×10^{-5} 3×10^{-5}
40	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates Fatty acid derivatives Ethoxylated nonylphenol	3×10^{-1} 3×10^{-1}	2 2	9×10^{-5} 9×10^{-5}

[1] A blank space in the table indicates that there were no releases to air because the chemical would not evaporate readily.

Surface Water

Releases to surface water are those releases discharged through a drain at a printing facility, or at a laundry facility laundering rags from the printing facility that end up going to public sewers or Publicly Owned Treatment Works (POTWs). This discharge is treated before being released. The effectiveness of the treatment determined so that the amount actually getting through to the receiving water body can be calculated. The receiving water will dilute the discharge from the POTW, and a stream concentration can be calculated using stream flow information. Stream in this context means the receiving body of water, and are creeks and rivers as well as streams.

Average stream concentrations are used to calculate average drinking water consumption. Many public water supplies are drawn from the local streams and rivers; the concentration in the stream is the concentration which people will ingest. People on average drink two liters of water a day. Remember that many commercially-prepared beverages are still made with local water at the bottling plant.

Since there are many chemicals which accumulate in living organisms (bioaccumulation), the amount of the chemical from eating fish living in the same streams and rivers is calculated. The ability of a chemical to bioaccumulate may be measured or estimated, and that property is called the bioaccumulation factor. For certain kinds of chemicals, food consumption may deliver very high doses because of the cumulative nature. We use the bioconcentration factor and the average amount of fish eaten per person per day to calculate an average amount of chemical ingested by people on a daily basis (Table 3-5).

The other issue for surface water is the effect that a chemical may have on aquatic organisms, from algae to fish. If the food chain is broken in a stream, the consequences are dire. No algae, no fish. A healthy stream with many organisms will have a better ability to handle chemical releases than one whose quality is already compromised. The organisms lower on the food chain, such as algae, tend to have shorter lives, making shorter exposure time periods more critical. Since concentrations will vary with the stream flow, there may be periods of lower flow conditions where the same amount released as on a regular flow situation will cause problems. We use historical stream data to try to predict how often this will happen. For lithographers, since most do not need to have their own wastewater permit and more typically send their water to the local treatment plant, we use the information for the wastewater treatment plants to calculate the concentrations.

Local Exposure: For the single facility impact to be calculated for a real facility, the stream to which the local POTW discharges should be known. Just as there are variations in facility sizes, there are variations in stream flows, and stream flows vary with time. The impact of this on this assessment is that more than one concentration needs to be calculated. Chronic effects, such as cancer, require average concentrations to be used. Since the average (mean) stream flows depends on what stream is being used, we select two averages to calculate - the average concentration for an mid-sized stream (50th percentile mean flow), and the average concentration for a small stream (10th percentile mean flow). For acute concerns and for ecological concerns, we calculated high concentrations which occur under low flow conditions. Specifically, low flow is the lowest flow that continues for seven consecutive days in ten years. However, we only calculate the low for small streams (10th percentile low flow).

The actual flows used in this assessment are 499 million liters per day for the 50th percentile harmonic mean flow, 66 million liters per day for 10th percentile mean flow, and 1 million liters per day for 10th percentile low flow.

Since an individual may ingest both drinking water and fish, there are multiple potential doses to evaluate.

To calculate stream concentration in µg/L, use the following formula:

$$\text{Stream Concentration} = \frac{\text{Release in kg/site/day x (1-Removal) x 1000}}{\text{Streamflow in million liters per day}}$$

or,

$$\text{Stream Concentration} = \frac{\text{Release after treatment in kg/site/day x 1000}}{\text{Streamflow in million liters per day}}$$

Because the flow data we use are measured by the U.S. Geological Survey (USGS) below any discharger on that segment of the stream (technically at the bottom of the reach), it already includes water from any POTW on that segment. For large streams this is not an important consideration, but for POTWs on small streams, it becomes contentious. A POTW with an internal plant flow of 10 million liters per day releasing to a stream which has a low flow of 10 million liters per day is not insignificant; it is all of the receiving stream's water. Based on the data, there are a significant number of POTWs for which this appears to be the case.

To calculate how much a person will ingest through drinking water in mg per year, use the formula:

Yearly Potential Dose Rate = Stream concentration in µg per liter x 2 liters of water per day x Days of release per year x 0.001

To calculate the potential amount taken through eating seafood in mg per year, use the following formula:

Yearly Potential Dose Rate = Stream concentration in µg per liter x Bioconcentration factor x 16.9 grams of fish per day x Days of release per year x 10^{-6}

The formula above does not consider removal during drinking water treatment. Public drinking water treatment is designed primarily to prevent biological contamination of drinking water and does not necessarily remove chemicals from the water. For most chemicals, drinking water treatment is not an effective mechanism. An exception to this is where an activated charcoal filter is used, such as on a private residential tap, which will remove a significant portion of the organic chemicals in the water.

The bioconcentration factor is a chemical-specific property. It is calculated with the environmental fate properties. The chemicals are assumed to be released 250 days per year.

Cumulative releases to the same POTW may be estimated by counting the number of lithographers in an area and distributing the releases across all the POTWs in the area. We have to assume that the releases are for the same products, or very similar products. As for air, this cumulative number is expected to be far more significant than the amount for any single lithographer. Again, Denver is the city used as an example (Table 3-6). Releases from all of the 235 lithographers in the city of Denver are assumed to go from the Denver Metro Wastewater Reclamation District into the South Platte River. The concentrations are calculated for harmonic mean flow of 875 million liters per day - which is the average or typical flow for the river, and for the low flow of 590 million liters per day - the lowest flow for seven consecutive days in ten years. Downstream from the discharge are drinking water intakes for the City of Broomfield and the City of Thornton.

Uncertainty

Within our scenario, there are specific parameters which affect final concentrations and therefore final exposures more than others. Since we are using the estimates for comparison, the single most important factor is the amount of the substance released per formulation. For water releases, the second most uncertain factor is the volume of water in the receiving stream, followed by the amount of substance removed in waste water treatment. In actuality, river flows vary continuously, so even a constant and steady flow of a specific chemical into the water will have variations in concentration. Some waste water treatment plants will remove more of a chemical than others, and even vary within the same plant at different times. The difference that this

Table 3-5. Stream Concentrations and Residential Population Potential Doses from Single Facility Blanket Wash Releases

Form. Number	Chemical Components	Daily Release[1] (kg/day)	Daily Release After POTW Treatment [1] (kg/day)	Stream concentrations[1] (mg/L)			Drinking Water Human Potential Dose Rates[2] (mg/year)		Fish Ingestion Human Potential Dose Rates[2] (mg/year)	
				50th %ile Mean flow	10th %ile Mean flow	10th %ile Low flow	50th %ile	10th %ile	50th %ile	10th %ile
1	Fatty acid derivatives									
	Alkoxylated alcohols									
3	Hydrocarbons, petroleum distillates									
	Fatty acid derivatives	6.1×10^{-1}	3.6×10^{-2}	7×10^{-5}	6×10^{-4}	4×10^{-2}	4×10^{-2}	3×10^{-1}	1×10^{2}	1×10^{3}
	Hydrocarbons, aromatic									
	Alkyl benzene sulfonates	1.5×10^{-1}	2.6×10^{-2}	5×10^{-5}	4×10^{-4}	3×10^{-2}	3×10^{-2}	2×10^{-1}	6×10^{-1}	4
4	Terpenes									
	Ethoxylated nonylphenol[3]	1.56	8×10	2×10^{-4}	1.0×10^{-3}	8.0×10^{-2}	8×10^{-2}	6×10^{-1}		
5	Water									
	Hydrocarbons, aromatic									
	Ethylene glycol ethers									
	Ethoxylated nonylphenol[3]	2.0×10^{-1}	1×10^{-2}	2×10^{-5}	2×10^{-4}	1.0×10^{-2}	1×10^{-2}	8×10^{-2}		
	Alkyl benzene sulfonates	1.2×10^{-1}	2.4×10^{-3}	5×10^{-6}	3.9×10^{-5}	2.6×10^{-3}	2.6×10^{-3}	2.5×10^{-2}	1×10^{-2}	1×10^{-2}
	Alkoxylated alcohols	6.0×10^{-2}	5.9×10^{-2}	1×10^{-4}	9×10^{-4}	6×10^{-2}	6×10^{-2}	5×10^{-1}	9×10^{-2}	7×10^{-1}
	Alkali/salts	2.0×10^{-2}	0	0	0	0	0	0	0	0
6	Fatty acid derivatives	1.3	7.9×10^{-2}	2×10^{-4}	1×10^{-3}	8×10^{-2}	8×10^{-2}	6×10^{-1}	3×10^{2}	2×10^{3}
	Hydrocarbons, petroleum distillates									
	Hydrocarbons, aromatic									
	Alkyl benzene sulfonates	1.0×10^{-1}	3.0×10^{-3}	6×10^{-6}	5×10^{-5}	3×10^{-3}	3×10^{-3}	2×10^{-2}	0	0
7	Terpenes									
	Ethoxylated nonylphenol[3]	6.0×10^{-2}	3×10^{-3}	6×10^{-6}	5×10^{-5}	3×10^{-3}	3×10^{-3}	2×10^{-2}		
	Alkoxylated alcohols	6.0×10^{-2}	9×10^{-3}	2×10^{-5}	1×10^{-4}	9×10^{-3}	9×10^{-3}	7×10^{-2}	0	0
8	Water									
	Hydrocarbons, aromatic									
	Propylene glycol ethers									
	Ethoxylated nonylphenol[3]	1.7×10^{-1}	9×10^{-3}	2×10^{-5}	1×10^{-4}	9.0×10^{-3}	9×10^{-3}	6×10^{-2}		
	Alkyl benzene sulfonates	3.64×10^{-1}	5.332×10^{-2}	1.11×10^{-4}	8.08×10^{-4}	4.95×10^{-2}	4.95×10^{-2}	3.7×10^{-1}	1×10^{-2}	9×10^{-2}
	Alkoxylated alcohols	5.2×10^{-2}	5.1×10^{-2}	1×10^{-4}	8×10^{-4}	5×10^{-2}	5×10^{-2}	4×10^{-1}	8×10^{-2}	6×10^{-1}
	Alkali/salts	1.6×10^{-2}	0	0	0	0	0	0	0	0

Form. Number	Chemical Components	Daily Release[1] (kg/day)	Daily Release After POTW Treatment[1] (kg/day)	Stream concentrations[1] (mg/L)			Drinking Water Human Potential Dose Rates[2] (mg/year)		Fish Ingestion Human Potential Dose Rates[2] (mg/year)	
				50th %ile Mean flow	10th %ile Mean flow	10th %ile Low flow	50th %ile	10th %ile	50th %ile	10th %ile
9	Fatty acid derivatives	1.6	9.7×10^{-2}	2×10^{-4}	1×10^{-3}	1×10^{-1}	1×10^{-1}	7×10^{-1}	4×10^{2}	3×10^{3}
	Water									
	Ethoxylated nonylphenol[3]	6.0×10^{-2}	3×10^{-3}	6×10^{-6}	5×10^{-5}	3×10^{-3}	3×10^{-3}	2×10^{-2}		
10	Fatty acid derivatives	5.6×10^{-1}	3.4×10^{-2}	7×10^{-5}	5×10^{-4}	3×10^{-2}	3×10^{-2}	3×10^{-1}	1×10^{2}	1×10^{3}
	Water									
11	Fatty acid derivatives	1.0	6.0×10^{-2}	1×10^{-4}	9×10^{-4}	6×10^{-2}	6×10^{-2}	5×10^{-1}	2×10^{2}	2×10^{2}
	Hydrocarbons, petroleum distillates									
	Hydrocarbons, aromatic									
	Alkyl benzene sulfonates	9.2×10^{-2}	1.6×10^{-2}	3×10^{-5}	2×10^{-4}	2×10^{-2}	2×10^{-2}	1×10^{-1}	0	0
12	Hydrocarbons, petroleum distillates									
14	Fatty acid derivatives	2.2×10^{-1}	1.3×10^{-2}	3×10^{-5}	2×10^{-4}	1×10^{-2}	1×10^{-2}	1×10^{-1}	5×10^{1}	4×10^{2}
	Propylene glycol ethers									
16	Terpenes									
17	Ethoxylated nonylphenol[3]	4.4×10^{-2}	2×10^{-3}	4×10^{-6}	3×10^{-5}	2×10^{-3}	2×10^{-3}	2×10^{-2}		
	Glycols									
	Fatty acid derivatives	2.0×10^{-2}	1.2×10^{-3}	2×10^{-6}	2×10^{-5}	1×10^{-3}	1×10^{-3}	9×10^{-3}	5	3
	Alkali/salts	1.2×10^{-2}								
	Water									
18	Fatty acid derivatives	9.0×10^{-1}	5.4×10^{-2}	1×10^{-4}	8×10^{-4}	5×10^{-2}	5×10^{-2}	4×10^{-1}	2×10^{2}	2×10^{3}
	Hydrocarbons, petroleum distillates									
	Hydrocarbons, aromatic									
	Dibasic esters									
	Esters/lactones									
	Alkyl benzene sulfonates	9.2×10^{-2}	1.6×10^{-2}	3×10^{-5}	2×10^{-4}	2×10^{-2}	2×10^{-2}	1×10^{-1}	0	0
19	Fatty acid derivatives	7.3×10^{-1}	4.4×10^{-2}	9×10^{-5}	7×10^{-4}	4×10^{-2}	4×10^{-2}	3×10^{-1}	2×10^{2}	1×10^{3}
	Propylene glycol ethers									
20	Hydrocarbons, petroleum distillates									
	Hydrocarbons, aromatic									
	Alkyl benzene sulfonates	1.0 x 10	3.9×10^{-2}	$8^{-1} \times 10^{-5}$	6×10^{-4}	4×10^{-2}	4×10^{-2}	3×10^{-1}	0	0
21	Hydrocarbons, aromatic									
	Hydrocarbons, petroleum distillates									
	Fatty acid derivatives	1.0	1.0 x 10	2×10^{-5}	2×10^{-4}	1×10^{-2}	1×10^{-2}	8×10^{-2}	$^{-2}$ 4×10^{1}	3×10^{2}

Form. Number	Chemical Components	Daily Release[1] (kg/day)	Daily Release[1] After POTW Treatment (kg/day)	Stream concentrations[1] (mg/L)			Drinking Water Human Potential Dose Rates[2] (mg/year)		Fish Ingestion Human Potential Dose Rates[2] (mg/year)	
				50th %ile Mean flow	10th %ile Mean flow	10th %ile Low flow	50th %ile	10th %ile	50th %ile	10th %ile
22	Fatty acid derivatives	1.2	6.9 x 10	$1^{2} \times 10^{-4}$	1×10^{-3}	7×10^{-2}	7×10^{-2}	5×10^{2}	3×10^{2}	2×10^{3}
	Hydrocarbons, aromatic									
23	Terpenes									
	Nitrogen heterocyclics									
	Alkoxylated alcohols									
24	Terpenes									
	Ethylene glycol ethers									
	Ethoxylated nonylphenol[3]	9.2×10^{-2}	5×10^{-3}	9×10^{-6}	7×10^{-5}	5×10^{-3}	5×10^{-3}	4×10^{-2}		
	Alkyl benzene sulfonates	1.4×10^{-1}	4.2×10^{-3}	8×10^{-6}	6×10^{-5}	4×10^{-3}	4×10^{-3}	3×10^{-2}	0	0
	Alkali/salts	9.2×10^{-2}	1.6×10^{-2}	3×10^{-5}	2×10^{-4}	2×10^{-2}	2×10^{-2}	1×10^{-1}	0	0
25	Terpenes									
	Esters/lactones									
26	Fatty acid derivatives	6.1	1.241×10^{-1}	2.08×10^{-4}	2.06×10^{-3}	1.04×10^{-1}	1.04×10^{-1}	9.3×10^{-1}	5.006×10^{2}	3.005×10^{3}
	Esters/lactones	1.03×10^{-1}	4.1×10^{-3}	8×10^{-6}	6×10^{-5}	4×10^{-3}	4×10^{-3}	3×10^{-2}	0	0
27	Terpenes									
28	Hydrocarbons, petroleum distillates									
29	Fatty acid derivatives	2.1	1.3×10^{-1}	3×10^{-4}	2×10^{-3}	1×10^{-1}	1×10^{-1}	1	5×10^{2}	4×10^{3}
30	Hydrocarbons, aromatic									
	Propylene glycol ethers									
31	Hydrocarbons, aromatic									
	Hydrocarbons, petroleum distillates									
32	Hydrocarbons, petroleum distillates									
33	Hydrocarbons, petroleum distillates									
	Hydrocarbons, aromatic									
	Propylene glycol ethers									
34	Water									
	Terpenes									
	Hydrocarbons, petroleum distillates									
	Alkoxylated alcohols	1.7×10^{-1}	2.9×10^{-2}	6×10^{-5}	4×10^{-4}	3×10^{-2}	3×10^{-2}	2×10^{-1}	0	0
	Fatty acid derivatives	1.7×10^{-1}	1.7×10^{-2}	3×10^{-5}	3×10^{-4}	2×10^{-2}	2×10^{-2}	1×10^{-1}	2×10^{-2}	2×10^{-1}

Form. Number	Chemical Components	Daily Release[1] (kg/day)	Daily Release After POTW Treatment[1] (kg/day)	Stream concentrations[1] (mg/L)			Drinking Water Human Potential Dose Rates[2] (mg/year)		Fish Ingestion Human Potential Dose Rates[2] (mg/year)	
				50th %ile Mean flow	10th %ile Mean flow	10th %ile Low flow	50th %ile	10th %ile	50th %ile	10th %ile
35	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic									
36	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Propylene glycol ethers	1.5	9.0×10^{-2}	2×10^{-4}	1×10^{-3}	9×10^{-2}	9×10^{-2}	7×10^{-1}	3×10^{2}	3×10^{3}
37	D. I. Water Hydrocarbons, petroleum distillates Hydrocarbons, aromatic									
38	Hydrocarbons, petroleum distillates Alkoxylated alcohols Fatty acid derivatives									
39	Water Hydrocarbons, petroleum distillates Propylene glycol ethers Alkanolamines Ethylene glycol ethers	6.8×10^{-2}	1.2×10^{-2}	2×10^{-5}	2×10^{-4}	1×10^{-2}	1×10^{-2}	9×10^{-2}	0	0
40	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates Fatty acid derivatives Ethoxylated nonylphenol[3]	1.4 8.8×10^{-2}	0 4×10^{-3}	0 9×10^{-6}	0 7×10^{-5}	0 4×10^{-3}	0 4×10^{-3}	0 3×10^{-2}	0	0

[1] A blank space in these columns indicates that there were no releases to water expected for this chemical in this formulation.

[2] A blank in the drinking water columns of this table indicates that there are no exposures expected from this chemical due to people drinking water. This may be due to either no releases to water expected, or the chemical may be completely removed during wastewater treatment, and therefore, is not expected to be released to the stream or river from the POTW. An additional blank in the Fish Ingestion columns means that a bioaccumulation factor was not available for this chemical.

[3] Based on testing data (Weeks, A.J. et al. 1996. *Proceedings of the CESIO 4th World Surfactants Congress, Barcelona, Spain.* Brussels, Belgium: European Committee on Surfactants and Detergents, pp. 276-291.), the original estimate of POTW removal has been changed from 100% reported in the draft document to 95% in the final report. This revision results in increased estimates of the releases from POTWs to surface waters of ethoxylated nonylphenols. When the releases to surface water are compared with the concern concentration set at the default value of 0.001 mg/L, the formulations containing ethoxylated nonylphenols (formulations 4, 5, 7, 8, 9, 17, 24, and 40) present concerns to aquatic species that were not reported in the draft CTSA.

Table 3-6. Stream Concentrations and Residential Population Potential Dose Rates from Denver Lithography Blanket Wash Releases

Form. No.	Chemical Components	Expected Total Release for Denver, CO (kg/day)[1]	After Treatment Total Release for Denver, CO (kg/day)[1]	Stream Concentration South Platte River (mg/L)		Human Potential Dose Rates (mg/year)[2]	
				Mean Flow	Low Flow	From Water	From Fish Ingestion
1	Fatty acid derivatives						
	Alkoxylated alcohols						
3	Hydrocarbons, petroleum distillates						
	Fatty acid derivatives	1.4×10^{2}	8.6	1×10^{-2}	1×10^{-2}	5	2×10^{4}
	Hydrocarbons, aromatic						
	Alkyl benzene sulfonates	36	6.1	7×10^{-3}	1×10^{-2}	3	80
4	Terpenes						
	Ethoxylated nonylphenol[3]	73	3.7	4×10^{-3}	6×10^{-3}	2	
5	Water						
	Hydrocarbons, aromatic						
	Ethylene glycol ethers						
	Ethoxylated nonylphenol[3]	47	2.4	3×10^{-3}	4×10^{-3}	1	
	Alkyl benzene sulfonates	28	5.6×10^{-1}	7×10^{-4}	9×10^{-4}	2.8×10^{-1}	2
	Alkoxylated alcohols	14	14	2×10^{-2}	2×10^{-2}	8	10
	Alkali/salts	4.7	0.0	0	0	0	
6	Fatty acid derivatives	3.1×10^{2}	19	2×10^{-2}	3×10^{-2}	10	4×10^{4}
	Hydrocarbons, petroleum distillates						
	Hydrocarbons, aromatic						
	Alkyl benzene sulfonates	24	7.1×10^{-1}	8×10^{-4}	1×10^{-3}	4×10^{-1}	
7	Terpenes						
	Ethoxylated nonylphenol[3]	14	0.7	8×10^{-4}	1×10^{-3}	0.4	
	Alkoxylated alcohols	14	2.1	2×10^{-3}	4×10^{-3}	1	
8	Water						
	Hydrocarbons, aromatic						
	Propylene glycol ethers						
	Alkyl benzene sulfonates	85	12.22	1.2×10^{-2}	2.4×10^{-2}	7.07	2
	Ethoxylated nonylphenol[3]	40	2.0	2×10^{-3}	3×10^{-3}	1	
	Alkoxylated alcohols	12	12	1×10^{-2}	2×10^{-2}	7	10
	Alkali/salts	3.8	0.0	0	0	0	
9	Fatty acid derivatives	3.8×10^{2}	23	3×10^{-2}	4×10^{-2}	10	5×10^{4}
	Water						
	Ethoxylated nonylphenol[3]	14	0.7	8×10^{-4}	1×10^{-3}	4	
10	Fatty acid derivatives	1.3×10^{2}	7.9	9×10^{-3}	1×10^{-2}	5	2×10^{4}
	Water						
11	Fatty acid derivatives	2.3×10^{2}	14	2×10^{-2}	2×10^{-2}	8	3×10^{4}
	Hydrocarbons, petroleum distillates						
	Hydrocarbons, aromatic						
	Alkyl benzene sulfonates	22	3.7	4×10^{-3}	6×10^{-3}	2	
12	Hydrocarbons, petroleum distillates						
14	Fatty acid derivatives	51	3.0	3×10^{-3}	5×10^{-3}	2	7×10^{3}
	Propylene glycol ethers						
16	Terpenes						

Form. No.	Chemical Components	Expected Total Release for Denver, CO (kg/day)[1]	After Treatment Total Release for Denver, CO (kg/day)[1]	Stream Concentration South Platte River (mg/L)		Human Potential Dose Rates (mg/year)[2]	
				Mean Flow	Low Flow	From Water	From Fish Ingestion
17	Ethoxylated nonylphenol[3] Glycols Fatty acid derivatives Alkali/salts Water	10 4.7	0.5 2.8×10^{-1}	6×10^{-4} 3×10^{-4}	8×10^{-4} 5×10^{-4}	0.3 2×10^{-1}	 6×10^{2}
18	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Dibasic esters Esters/lactones Alkyl benzene sulfonates	2.1×10^{2} 22	13 3.7	1×10^{-2} 4×10^{-3}	2×10^{-2} 6×10^{-3}	7 2	3×10^{4}
19	Fatty acid derivatives Propylene glycol ethers	1.7×10^{2}	10	1×10^{-2}	2×10^{-2}	6	2×10^{4}
20	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Alkyl benzene sulfonates	 24	 9.2	 1×10^{-2}	 2×10^{-2}	 5	
21	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates Fatty acid derivatives	 2.4×10^{2}	 2.4	 3×10^{-3}	 4×10^{-3}	 1	 6×10^{3}
22	Fatty acid derivatives Hydrocarbons, aromatic	2.7×10^{2}	16	2×10^{-2}	3×10^{-2}	9	4×10^{4}
23	Terpenes Nitrogen heterocyclics Alkoxylated alcohols						
24	Terpenes Ethylene glycol ethers Ethoxylated nonylphenol[3] Alkyl benzene sulfonates Alkali/salts	 22 33 22	 1.1 9.9×10^{-1} 3.7	 1×10^{-3} 1×10^{-3} 4×10^{-3}	 2×10^{-3} 2×10^{-3} 6×10^{-3}	 6×10^{-1} 6×10^{-1} 2	
25	Terpenes Esters/lactones						
26	Fatty acid derivatives Esters/lactones	5.66×10^{2} 2.36×10^{2}	2.896×10^{1} 9.6×10^{-1}	3.1×10^{-2} 1×10^{-3}	5.2×10^{-2} 2×10^{-3}	20.5 5×10^{-1}	6.008×10^{4} 0
27	Terpenes						
28	Hydrocarbons, petroleum distillates						
29	Fatty acid derivatives	5.0×10^{2}	30	3×10^{-2}	5×10^{-2}	20	6×10^{4}
30	Hydrocarbons, aromatic Propylene glycol ethers						
31	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates						
32	Hydrocarbons, petroleum distillates						
33	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Propylene glycol ethers						

Form. No.	Chemical Components	Expected Total Release for Denver, CO (kg/day)[1]	After Treatment Total Release for Denver, CO (kg/day)[1]	Stream Concentration South Platte River (mg/L)		Human Potential Dose Rates (mg/year)[2]	
				Mean Flow	Low Flow	From Water	From Fish Ingestion
34	Water Terpenes Hydrocarbons, petroleum distillates Alkoxylated alcohols Fatty acid derivatives	 39 39	 6.7 3.9	 8×10^{-3} 5×10^{-3}	 1×10^{-2} 7×10^{-3}	 4 2	 3
35	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic						
36	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Propylene glycol ethers	3.5×10^{2}	21	2×10^{-2}	4×10^{-2}	10	5×10^{4}
37	Water Hydrocarbons, petroleum distillates Hydrocarbons, aromatic						
38	Hydrocarbons, petroleum distillates Alkoxylated alcohols Fatty acid derivatives						
39	Water Hydrocarbons, petroleum distillates Propylene glycol ethers Alkanolamines Ethylene glycol ethers	 16	 2.7	 3×10^{-3}	 5×10^{-3}	 2	
40	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates Fatty acid derivatives Ethoxylated nonylphenol[3]	 3.3×10^{2} 21	 0.0 1.1×10^{-3}	 0 1.2×10^{-3}	 0 1.9×10^{-3}	 0 0.6	 0

[1] A blank space in these columns indicates that there were no releases to water expected for this chemical in this formulation.

[2] A blank in the drinking water columns of this table indicates that there are no exposures expected from this chemical due to people drinking water. This may be due to either no releases to water expected, or the chemical may be completely removed during wastewater treatment, and therefore, is not expected to be released to the stream or river from the POTW. An additional blank in the Fish Ingestion columns means that a bioaccumulation factor was not available for this chemical.

[3] Based on testing data (Weeks, J.A. et al. 1996. *Proceedings of the CESIO 4th World Surfactants Congress, Barcelona, Spain.* Brussels, Belgium: European Committee on Surfactants and Detergents, pp. 276-291.), the original estimate of POTW removal has been changed from 100% reported in the draft document to 95% in the final report. This revision results in increased estimates of the releases from POTWs to surface waters of ethoxylated nonylphenols. When the releases to surface water are compared with the concern concentration set at the default value of 0.001 mg/L, the formulations containing ethoxylated nonylphenols (formulations 4, 5, 7, 8, 9, 17, 24, and 40) present concerns to aquatic species that were not reported in the draft CTSA.

makes in the final concentration is not as significant as the volume of the chemical released, i.e. the difference between fifty percent and sixty percent removal of a chemical.

Septic Systems

When examining the business census data for lithographers and the EPA's data for waste water treatment facilities, it was noted that there are counties which do not have any POTWs. While some of the Agency's data is probably in error, there are still a significant minority of lithographers who do not appear to release water to a waste water treatment plant. These printers are assumed to release to septic systems or have no water releases at all. The releases of this type are not modeled in this assessment. Some general guidelines may be used to determine if there will be exposure to any of the blanket wash chemicals from septic system seepage. Each chemical will have an estimated potential migration to ground water, usually used for landfill assessments. This can be directly applied to septic systems, because the potential to migrate to ground water will be the same. Of course the individual characteristics of the system will determine the actual speed that each chemical travels into the ground water. If the septic system is relatively leaky, and the ground water table is relatively high, the time that a chemical takes to get into the ground water will be shorter than for a septic system which is well sealed and where the ground water table is low.

Landfill

Our usual techniques for estimating cumulative exposures from landfill releases are not applicable to printing. For large-scale industrial processes, we assume that one facility sends waste to a landfill via a waste handler. For the printing industry, it is not reasonable to simplify the situation to that extent. A lack of data limits the determination of exposures. For instance, we do not know how many printers are sending what types of wastes to any given landfill. Some printers send part of their wastes to a hazardous waste handler, and another portion to the county landfill. For these reasons, although the exposures from landfill releases may be significant, we cannot calculate exposures from landfill seepage and migration into ground water. However, we can give the expected fate for the chemical in the landfill - will the chemical migrate to ground water rapidly, moderately or negligibly.

3.4 RISK CHARACTERIZATION

3.4.1 Background

Assessment of the human health risks presented by chemical substances includes the following components of analysis:

1) Hazard Identification is the process of determining whether exposure to a chemical can cause an adverse health effect and whether the adverse health effect is likely to occur in humans.

2) Dose-response Assessment is the process of defining the relationship between the dose of a chemical received and the incidence of adverse health effects in the exposed population. From the quantitative dose-response relationship, toxicity values are derived that are used in the risk characterization step to estimate the likelihood of adverse effects occurring in humans at different exposure levels.

3) Exposure Assessment identifies populations exposed to a chemical, describes their composition and size, and presents the types, magnitudes, frequencies, and durations of exposure to the chemical.

4) Risk Characterization integrates hazard and exposure information into quantitative and qualitative expressions of risk. A risk characterization includes a description of the assumptions, scientific judgments, and uncertainties embodied in the assessment.

Quantitative Expressions of Hazard and Risk

The manner in which estimates of hazard and risk are expressed depends on the nature of the hazard and the types of data upon which the assessment is based. For example, cancer risks are most often expressed as the probability of an individual developing cancer over a lifetime of exposure to the chemical in question. Risk estimates for adverse effects other than cancer are usually expressed as the ratio of a toxicologic potency value to an estimated dose or exposure level. A key distinction between cancer and other toxicologic effects is that most carcinogens are assumed to have no dose threshold, i.e., no dose or exposure level can be presumed to be without some risk. Other toxicologic effects are generally assumed to have a dose threshold, i.e., a dose or exposure level below which a significant adverse effect is not expected.

Cancer Hazard and Risk

EPA employs a "weight-of-evidence" approach to determine the likelihood that a chemical is a human carcinogen. Each chemical evaluated is placed into one of the five weight-of-evidence categories listed below.

Group A --	human carcinogen
Group B --	probable human carcinogen. B1 indicates limited human evidence; B2 indicates sufficient evidence in animals and inadequate or no evidence in humans.
Group C --	possible human carcinogen
Group D --	not classifiable as to human carcinogenicity
Group E --	evidence of noncarcinogenicity for humans

When the available data are sufficient for quantitation, EPA develops an estimate of the chemical's carcinogenic potency. EPA "slope factors" express carcinogenic potency in terms of the estimated upper-bound incremental lifetime risk per mg/kg average daily dose. "Unit risk" is a similar measure of potency for air or drinking water concentrations and is expressed as risk per $\mu g/m^3$ in air or as risk per μg/L in water for continuous lifetime exposures.

Cancer risk is calculated by multiplying the estimated dose or exposure level by the appropriate measure of carcinogenic potency. For example an individual with a lifetime average daily dose of 0.3 mg/kg of a carcinogen with a potency of 0.02 mg/kg/day would experience a lifetime cancer risk of 0.006 from exposure to that chemical. In general, risks from exposures to more than one carcinogen are assumed to be additive, unless other information points toward a different interpretation.

Chronic Health Risks

Because adverse effects other than cancer and genetic toxicity are generally assumed to have a dose or exposure threshold, a different approach is needed to evaluate toxicologic potency and risk for these "systemic effects." "Systemic toxicity" means an adverse effect on any organ system following absorption and distribution of a toxicant to a site in the body distant from the toxicant's entry point. EPA uses the "Reference Dose" approach to evaluate chronic (long-term) exposures to systemic toxicants. The Reference Dose (RfD) is defined as "an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects during a lifetime" and is expressed as a mg/kg/day dose. The RfD is usually based on the most sensitive known effect, i.e., the effect that occurs at the lowest dose. EPA calculates a comparable measure of potency for continuous inhalation exposures called a Reference Concentration or RfC, expressed as a mg/m^3 air concentration. Although some RfDs and RfCs are based on actual human data, they are most often calculated from results obtained in chronic or subchronic animal studies. The basic approach for deriving an RfD or RfC involves determining a "no-observed-adverse-effect level (NOAEL)" or "lowest-observed-adverse-effect level (LOAEL)" from an appropriate toxicologic or epidemiologic study and then applying various uncertainty factors and modifying factors to arrive at the RfD/RfC. Each factor represents a specific area of uncertainty. For example, an RfD based on a NOAEL from a long-term animal study may incorporate a factor of 10 to account for the uncertainty in extrapolating from the test species to humans and another factor of 10 to account for the variation in sensitivity within the human population. An RfD based on a LOAEL typically contains another factor of 10 to account for the extrapolation from LOAEL to NOAEL. An additional modifying factor (between 1 and 10) is sometimes applied to account for uncertainties in data quality.

RfDs and RfCs can be used to evaluate risks from chronic exposures to systemic toxicants. EPA defines an expression of risk called a "Hazard Quotient" which is the ratio of the estimated chronic dose/exposure level to the RfD/RfC. Hazard Quotient values below unity imply that adverse effects are very unlikely to occur. The more the Hazard Quotient exceeds unity, the greater is the level of concern. However, it is important to remember that the Hazard Quotient is not a probabilistic statement of risk. A quotient of 0.001 does not mean that there is a one-in-a-thousand chance of the effect occurring. Furthermore, it is important to remember that the level of concern does not necessarily increase linearly as the quotient approaches or exceeds unity because the RfD/RfC does not provide any information about the shape of the dose-response curve.

An expression of risk that can be used when an RfD/RfC is not available is the "Margin-of-Exposure (MOE)." The MOE is the ratio of a NOAEL or LOAEL (preferably from a chronic study) to an estimated dose or exposure level. Interpretation of an MOE employs the same approach to uncertainty as the RfD does. An MOE value high enough to account for the uncertainties in extrapolating from the experimental data to a likely no-effect level in humans implies a low level of concern. For example, MOE values such as values greater than 100 for a NOAEL-based MOE (to account for interspecies and intraspecies variability) or 1000 for a LOAEL-based MOE (to account for interspecies and intraspecies variability and LOAEL to NOAEL extrapolation) indicate low concern. As the MOE decreases, the level of concern increases. As with the Hazard Quotient, it is important to remember that the MOE is not a probabilistic statement of risk.

Developmental Toxicity Risks

Because of the many unique elements associated with both the hazard and exposure components of developmental toxicity risk assessment, these risks are treated separately from other systemic toxicity risks.

EPA defines developmental toxicity as adverse effects on the developing organism that may result from exposure prior to conception, during prenatal development, or postnatally to the time of sexual maturation. Adverse developmental effects may be detected at any point in the life span of the organism. The major manifestations of developmental toxicity include: (1) death of the developing organism, (2) structural abnormality, (3) altered growth, and (4) functional deficiency.

There is a possibility that a single exposure may be sufficient to produce adverse developmental effects. Therefore, it is assumed that, in most cases, a single exposure at any of several developmental stages may be sufficient to produce an adverse developmental effect. In the case of intermittent exposures, examination of the peak exposure(s) as well as the average exposure over the time period of exposure is important.

EPA has derived RfDs and RfCs for developmental toxicants in a similar manner to the RfDs and RfCs for other systemic toxicants. The RfD_{DT} or RfC_{DT} is an estimate of a daily exposure to the human population that is assumed to be without appreciable risk of deleterious developmental effects. The use of the subscript DT is intended to distinguish these terms from the more common RfDs and RfCs that refer to chronic exposure situations for other systemic effects.

Developmental toxicity risk can be expressed as a Hazard Quotient (dose or exposure level divided by the RfD_{DT} or RfC_{DT}) or Margin-of-Exposure (NOAEL or LOAEL divided by the dose or exposure level), with careful attention paid to the exposure term, as described above.

NOTE: The closely related area of reproductive toxicity is also an important aspect of systemic toxicity. For purposes of this report, toxicity information on adult male and female reproductive systems will be assessed as part of the chronic toxicity risk.

Decision Criteria

"Concerns" are cases in which the estimated hazard quotient is ten or greater or in which the estimated margin-of-exposure (MOE) is much less than 100 (based on a no-observed adverse effect level (NOAEL)) or much less than 1000 (based on a lowest-observed adverse effect level (LOAEL)).

"Possible concerns" are cases in which the estimated hazard quotient is between one and ten or in which the estimated margin-of-exposure is slightly less than 100 (based on a no-observed adverse effect level) or slightly less than 1000 (based on a lowest-observed adverse effect level) or cases in which the concern is mitigated by other considerations such as absorption rates.

"Low or negligible concerns" are cases in which the estimated hazard quotient is less than one or in which the MOE_{NOAEL} is greater than 100 or the MOE_{LOAEL} is greater than 1000.

Assumptions and Uncertainties

Estimated doses assume 100 percent absorption. The actual absorption rate may be significantly lower, especially for dermal exposures to relatively polar compounds. The assessment used the most relevant toxicological potency factor available for the exposure under consideration. In some cases the only potency factor available was derived from a study employing a different route of exposure than the exposure being evaluated, e.g., oral RfD values were sometimes used to calculate Hazard Quotients for inhalation and dermal exposures. Most of the Margin-of-Exposure calculations presented in the assessment are based on toxicity data that have not been formally evaluated by the Agency. Because of the small contribution of inhalation exposure to the total dose (<1% for most chemicals), combined dose MOEs were not calculated.

Worker dermal exposure values should be regarded as “bounding estimates,” i.e., calculated exposures are expected to be higher than any actual exposure levels. Exposure estimates for all other pathways (worker inhalation, general population exposure via ambient air, drinking water and fish) should be regarded as “what if” estimates. The “what if” scenarios are based on information on product usage and work practices obtained from industry surveys. No actual measures of chemical release or exposure were available. The scenarios are intended to represent a plausible set of circumstances under which exposures could occur. However, not enough information is available to estimate the probability of these circumstances actually occurring. Thus, it is not possible to predict where the calculated values fall in the exposure distribution, i.e., the resulting exposure and risk estimates cannot be characterized as “central tendency,” “high end,” etc.

A number of the chemicals of concern have only a limited toxicologic data base. The calculated risks for trimethylbenzene, light aromatic naphtha, linalool, butyrolactone, Stoddard solvent, and diethanolamine are based on LOAEL values from studies that did not reach a NOAEL. The available studies on these chemicals are generally limited in scope and do not address all major toxicologic endpoints.

3.4.2 Ecological Risk

The basic elements of ecological risk assessment are similar to those employed in human health risk assessment. Because of the limited toxicological data available for the lithographic blanket wash chemicals, this report will only address ecological risks to aquatic species. Risks to terrestrial species will not be assessed. Quantitative evaluation of aquatic risks involves comparing a predicted ambient water concentration to a "concern concentration" for chronic exposures to aquatic species. The concern concentration may be based either on actual toxicologic test data on the subject chemical or on quantitative structure-activity relationship analysis of test data on similar chemicals. The concern concentration is typically expressed as a mg/L water concentration. Exposure concentrations below the concern concentration are assumed to present low risk to aquatic species. Exposures that exceed the concern concentration indicate a potential for adverse impact on aquatic species. The level of concern increases as the ratio of exposure concentration to concern concentration increases.

A number of formulations present concerns with respect to potential impacts on aquatic species resulting from water releases. Only two chemical classes had estimated concentrations in a hypothetical receiving stream (a relatively small stream at low flow conditions) that exceeded the “concern concentration” for that chemical class. Predictions based on actual streamflow data for the South Platte River support these conclusions. Most of the excesses in the hypothetical stream are also excesses in the South Platte River, in some cases at mean flow as well as low flow conditions.

The following two chemicals exceeded the aquatic concern concentrations: alkyl benzene sulfonates and ethoxylated nonylphenols, which are present in Formulations 3, 5, 6, 8, 11, 18, 20, and 24, and in Formulations 4, 5, 7, 8, 9, 17, 24, and 40, respectively.

A table of the concern concentration estimates for aquatic species follows (Table 3-7):

<u>Assumptions and Uncertainties</u>

All estimated water concentrations are based on release estimates developed from “what if” scenarios constructed from industry surveys and assumptions reviewed by industry experts of product usage and work practices. No actual measures of chemical release or exposure levels were available.

Table 3-7. Risks to Aquatic Species from Blanket Wash Chemicals

Form. Number	Chemical Components	Stream concentrations (mg/L)			Concern conc "cc" (mg/L)	Low[1] flow conc/ "cc"
		50th %ile Mean flow	10th %ile Mean flow	10th %ile Low flow		
1	Fatty acid derivatives					
	Alkoxylated alcohols					
3	Hydrocarbons, petroleum distillates					
	Fatty acid derivatives	7×10^{-5}	6×10^{-4}	4×10^{-2}	*	
	Hydrocarbons, aromatic					
	Alkyl benzene sulfonates	5×10^{-5}	4×10^{-4}	3×10^{-2}	1×10^{-3}	3×10^{1}
4	Terpenes					
	Ethoxylated nonylphenol[2]	1.56×10^{-4}	1.182×10^{-3}	7.8×10^{-2}	1×10^{-3}	78
5	Water					
	Hydrocarbons, aromatic					
	Ethylene glycol ethers					
	Ethoxylated nonylphenol[2]	2.0×10^{-5}	1.52×10^{-4}	1.0×10^{-2}	1×10^{-3}	10
	Alkyl benzene sulfonates	5×10^{-6}	3.9×10^{-5}	2.6×10^{-3}	2×10^{-3}	1
	Alkoxylated alcohols	1×10^{-4}	9×10^{-4}	6×10^{-2}	2×10^{-1}	3×10^{-1}
	Alkali/salts	0	0	0		
6	Fatty acid derivatives	2×10^{-4}	1×10^{-3}	8×10^{-2}	*	
	Hydrocarbons, petroleum distillates					
	Hydrocarbons, aromatic					
	Alkyl benzene sulfonates	6×10^{-6}	5×10^{-5}	3×10^{-3}	1×10^{-3}	3
7	Terpenes					
	Ethoxylated nonylphenol[2]	6×10^{-6}	4.5×10^{-5}	3.0×10^{-3}	1×10^{-3}	3
	Alkoxylated alcohols	2×10^{-5}	1×10^{-4}	9×10^{-3}	1×10^{-1}	9×10^{-2}
8	Water					
	Hydrocarbons, aromatic					
	Propylene glycol ethers					
	Alkyl benzene sulfonates	1.11×10^{-4}	8.08×10^{-4}	4.95×10^{-2}	$1\times10^{+1}$	5×10^{-1}
	Ethoxylated nonylphenol[2]	1.7×10^{-5}	1.29×10^{-4}	8.5×10^{-3}	1×10^{-3}	8.5
	Alkoxylated alcohols	1×10^{-4}	8×10^{-4}	5×10^{-2}	2×10^{-1}	3×10^{-1}
	Alkali/salts	0	0	0		
9	Fatty acid derivatives	2×10^{-4}	1×10^{-3}	1×10^{-1}	*	
	Water					
	Ethoxylated nonylphenol[2]	6×10^{-6}	4.5×10^{-5}	3×10^{-3}	1×10^{-3}	3
10	Fatty acid derivatives	7×10^{-5}	5×10^{-4}	3×10^{-2}	*	
	Water					
11	Fatty acid derivatives	1×10^{-4}	9×10^{-4}	6×10^{-2}	*	
	Hydrocarbons, petroleum distillates					
	Hydrocarbons, aromatic					
	Alkyl benzene sulfonates	3×10^{-5}	2×10^{-4}	2×10^{-2}	1×10^{-3}	$2\times10^{+1}$
12	Hydrocarbons, petroleum distillates					
13	Hydrocarbons, petroleum distillates					
	Terpenes					
14	Fatty acid derivatives	3×10^{-5}	2×10^{-4}	1×10^{-2}	*	
	Ethylene glycol ethers					
16	Terpenes					

Form. Number	Chemical Components	Stream concentrations (mg/L)			Concern conc "cc" (mg/L)	Low[1] flow conc/ "cc"
		50th %ile	10th %ile	10th %ile		
		Mean flow	Mean flow	Low flow		
17	Ethoxylated nonylphenol[2]	4×10^{-6}	3.3×10^{-5}	2.2×10^{-3}	1×10^{-3}	2.2
	Propylene glycol ethers					
	Fatty acid derivatives	2×10^{-6}	2×10^{-5}	1×10^{-3}	2	5×10^{-4}
	Alkali/salts					
	Water					
18	Fatty acid derivatives	1×10^{-4}	8×10^{-4}	5×10^{-2}	*	
	Hydrocarbons, petroleum distillates					
	Hydrocarbons, aromatic					
	Dibasic esters					
	Esters/lactones					
	Alkyl benzene sulfonates	3×10^{-5}	2×10^{-4}	2×10^{-2}	1×10^{-3}	$2\times10^{+1}$
19	Fatty acid derivatives	9×10^{-5}	7×10^{-4}	4×10^{-2}	*	
	Ethylene glycol ethers					
20	Hydrocarbons, petroleum distillates					
	Hydrocarbons, aromatic					
	Alkyl benzene sulfonates	8×10^{-5}	6×10^{-4}	4×10^{-2}	1×10^{-3}	$4\times10^{+1}$
21	Hydrocarbons, aromatic					
	Hydrocarbons, petroleum distillates					
	Fatty acid derivatives	2×10^{-5}	2×10^{-4}	1×10^{-2}	*	
22	Fatty acid derivatives	1×10^{-4}	1×10^{-3}	7×10^{-2}	*	
	Hydrocarbons, aromatic					
23	Terpenes					
	Nitrogen heterocyclics					
	Alkoxylated alcohols					
24	Terpenes					
	Ethylene glycol ethers					
	Ethoxylated nonylphenol[2]	9×10^{-6}	7×10^{-5}	4.6×10^{-3}	1×10^{-3}	4.6
	Alkyl benzene sulfonates	8×10^{-6}	6×10^{-5}	4×10^{-3}	3×10^{-2}	1×10^{-1}
	Alkali/salts	3×10^{-5}	2×10^{-4}	2×10^{-2}	9×10^{-2}	2×10^{-1}
25	Terpenes					
	Esters/lactones					
26	Fatty acid derivatives	2.08×10^{-4}	2.06×10^{-3}	1.04×10^{-1}	3×10^{-1}	
	Esters/lactones	8×10^{-6}	6×10^{-5}	4×10^{-3}	3×10^{-1}	1×10^{-2}
27	Terpenes					
28	Hydrocarbons, petroleum distillates					
29	Fatty acid derivatives	3×10^{-4}	2×10^{-3}	1×10^{-1}	*	
30	Hydrocarbons, aromatic					
	Ethylene glycol ethers					
31	Hydrocarbons, aromatic					
	Hydrocarbons, petroleum distillates					
32	Hydrocarbons, petroleum distillates					
33	Hydrocarbons, petroleum distillates					
	Hydrocarbons, aromatic					
	Propylene glycol ethers					

Form. Number	Chemical Components	Stream concentrations (mg/L) 50th %ile Mean flow	10th %ile Mean flow	10th %ile Low flow	Concern conc "cc" (mg/L)	Low[1] flow conc/ "cc"
34	Water Terpenes Hydrocarbons, petroleum distillates Alkoxylated alcohols Fatty acid derivatives	 6×10^{-5} 3×10^{-5}	 4×10^{-4} 3×10^{-4}	 3×10^{-2} 2×10^{-2}	 3×10^{-1} 7×10^{-2}	 1×10^{-1} 3×10^{-1}
35	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic					
36	Fatty acid derivatives Hydrocarbons, petroleum distillates Hydrocarbons, aromatic Propylene glycol ethers	2×10^{-4}	1×10^{-3}	9×10^{-2}	*	
37	Water Hydrocarbons, petroleum distillates Aliphatic hydrocarbon Hydrocarbons, aromatic					
38	Hydrocarbons, petroleum distillates Alkoxylated alcohols Fatty acid derivatives					
39	Water Hydrocarbons, petroleum distillates Propylene glycol ethers Alkanolamines Ethylene glycol ethers	 2×10^{-5}	 2×10^{-4}	 1×10^{-2}	 1	 1×10^{-2}
40	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates Fatty acid derivatives Ethoxylated nonylphenol[2]	 9×10^{-6}	 6.7×10^{-5}	 4.4×10^{-3}	 1×10^{-3}	 4.4

[1] Low flow concentration/concern concentration; reported as mg/L

[2] Based on testing data (Weeks, J.A. et al. 1996. *Proceedings of the CESIO 4th World Surfactants Congress, Barcelona, Spain.* Brussels, Belgium: European Committee on Surfactants and Detergents, pp. 276-291.) the original estimate of POTW removal has been changed from 100% reported in the draft document to 95% in the final report. This revision results in increased estimates of releases to surface water. When the releases to surface water are compared with the concern concentration set at the default value of 0.001 mg/L, the formulations containing ethoxylated nonylphenols (formulations 4, 5, 7, 8, 9, 17, 24 and 40) present concerns to aquatic species that were not reported in the draft CTSA.

* No effects expected at saturation.

3.4.3 Occupational Risks

Most of the formulations (27/37) present at least some concern for dermal exposures to workers. A wide variety of chemicals trigger these concerns, which appear to be driven primarily by relatively high potential exposure levels. The calculated risks overestimate the actual risks because of the use of bounding estimates of exposure and the assumption of 100% dermal absorption. However, the margins of exposure are so low (below 10 for a number of chemicals) for most of the chemicals of concern that it is very likely that most of the identified concerns would remain if more realistic exposure estimates were available. Also, most of the chemicals of concern, e.g., various petroleum hydrocarbons, glycol ethers, diethanolamine, are probably well-absorbed dermally.

Worker inhalation risks are very low for almost all of the formulations, reflective of the generally low exposure levels as seen in Table 3-8. Only one formulation (formulation number 3) triggered inhalation concerns.

A Margin-of-Exposure (MOE) or a Hazard Quotient (HQ) gives an estimate of the "margin of safety" between an estimated exposure level and the level at which adverse effects may occur. Hazard Quotient values below unity imply that adverse effects are very unlikely to occur. The more the Hazard Quotient exceeds unity, the greater is the level of concern. High MOE values such as values greater that 100 for a NOAEL-based MOE or 1000 for a LOAEL-based MOE imply a low level of concern. As the MOE decreases, the level of concern increases. The hazard values used in the HQ or MOE calculations were taken from Table 2-3. The exposure values used in the calculations were taken from Table 3-2. The absence of HQ or MOE values in this table indicates that insufficient hazard data were available to calculate a HQ or MOE for that chemical.

The calculated risk numbers should be viewed as low-confidence estimates because of the many uncertainties associated with both the hazard and exposure components of the calculation. However, most of the risk conclusions that follow can be regarded with moderate to high confidence because most of the conclusions are based on risk estimates that fall far above or far below standard risk benchmarks. Thus, the “true” risk value could vary substantially from the estimated value without changing the conclusion. In particular, conclusions of low concern generally can be regarded with high confidence because of the conservative approach (i.e. one that overestimates the risk) taken in the assessment. Conclusions based on small excesses of risk benchmarks should be viewed with low confidence, as should any conclusions based primarily on structure-activity predictions.

Table 3-8. Worker Occupational Risk Estimates

Form. Number	Chemical Components	Margin of Exposure (MOE)[1,2]	
		Dermal	Inhalation
1	Fatty acid derivatives		
	Alkoxylated alcohols		
3	Hydrocarbons, petroleum distillates		
	Fatty acid derivatives		
	Hydrocarbons, aromatic	10	4464
	Hydrocarbons, aromatic	1	33
	Hydrocarbons, aromatic	0.36 (HQ)	0.02 (HQ)
	Hydrocarbons, aromatic	1 (HQ)	0.02 (HQ)
	Alkyl benzene sulfonates		
4	Terpenes	5	236
	Ethoxylated nonylphenol	135	
	Ethoxylated nonylphenol	159	

Form. Number	Chemical Components	Margin of Exposure (MOE)[1,2]	
		Dermal	Inhalation
5	Water		
	Hydrocarbons, aromatic	10	1.8×10^{4}
	Ethylene glycol ethers	26	1.8×10^{5}
	Ethoxylated nonylphenol	117	
	Alkyl benzene sulfonates		
	Alkoxylated alcohols		
	Alkyl benzene sulfonates		
	Alkali/salts		
6	Fatty acid derivatives		
	Hydrocarbons, petroleum distillates	38	6233
	Hydrocarbons, aromatic		
	Alkyl benzene sulfonates		
7	Terpenes		
	Terpenes	22	1.8×10^{4}
	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes		
	Ethoxylated nonylphenol	318	
	Alkoxylated alcohols		
8	Water		
	Hydrocarbons, aromatic		
	Propylene glycol ethers	200	4.1×10^{4}
	Alkyl benzene sulfonates		
	Ethoxylated nonylphenol	135	
	Alkyl benzene sulfonates		
	Alkoxylated alcohols		
	Alkyl benzene sulfonates		
	Alkali/salts		
9	Fatty acid derivatives		
	Water		
	Ethoxylated nonylphenol	455	
10	Fatty acid derivatives		
	Water		
11	Fatty acid derivatives		
	Hydrocarbons, petroleum distillates	21	4429
	Hydrocarbons, aromatic		
	Alkyl benzene sulfonates		

Form. Number	Chemical Components	Margin of Exposure (MOE)[1,2]	
		Dermal	Inhalation
12	Hydrocarbons, petroleum distillates		
	Hydrocarbons, petroleum distillates	73	7.0×10^{4}
	Water		
14	Fatty acid derivatives		
	Propylene glycol ethers		
	Water		
16	Terpenes	22	1.8×10^{4}
	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes		
17	Ethoxylated nonylphenol	515	
	Propylene glycol ethers	0.05 (HQ)	6×10^{-6} (HQ)
	Fatty acid derivatives		
	Alkali/salts	5208	
	Water		
18	Fatty acid derivatives		
	Hydrocarbons, petroleum distillates	26	5803
	Hydrocarbons, aromatic		
	Dibasic esters	4	5405
	Dibasic esters	4	9091
	Dibasic esters	4	5263
	Esters/lactones		
	Alkyl benzene sulfonates		
19	Fatty acid derivatives		
	Propylene glycol ethers		
	Water		
20	Water		
	Hydrocarbons, petroleum distillates	84	9.4×10^{4}
	Hydrocarbons, aromatic		
	Alkyl benzene sulfonates		
21	Hydrocarbons, aromatic	13	4464
	Hydrocarbons, petroleum distillates	8	1336
	Fatty acid derivatives		
22	Fatty acid derivatives		
	Hydrocarbons, aromatic		
	Water		

Form. Number	Chemical Components	Margin of Exposure (MOE)[1,2]	
		Dermal	Inhalation
23	Terpenes	63	2.1×10^{4}
	Nitrogen heterocyclics	98	2.1×10^{4}
	Alkoxylated alcohols		
	Water		
24	Terpenes	28	7292
	Ethylene glycol ethers	83	7.8×10^{5}
	Ethoxylated nonylphenol	218	
	Alkyl benzene sulfonates	2	
	Alkali/salts		
	Water		
25	Terpenes		
	Terpenes	22	1.8×10^{4}
	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes		
	Esters/lactones	218	1.5×10^{4}
26	Fatty acid derivatives		
	Esters/lactones	45	
	Fatty acid derivatives	151	
	Esters/lactones		
27	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes		
	Terpenes	455	3.6×10^{5}
	Terpenes		
	Terpenes		
28	Hydrocarbons, petroleum distillates	7	110
29	Fatty acid derivatives		
30	Hydrocarbons, aromatic	4	5168
	Propylene glycol ethers		
	Water		
31	Hydrocarbons, aromatic	17	1.1×10^{4}
	Hydrocarbons, petroleum distillates		
32	Hydrocarbons, petroleum distillates		

Form. Number	Chemical Components	Margin of Exposure (MOE)[1,2]	
		Dermal	Inhalation
33	Hydrocarbons, petroleum distillates	10	1.0×10^{4}
	Hydrocarbons, aromatic	11	2.2×10^{4}
	Propylene glycol ethers	3322	3.6×10^{5}
	Water		
34	Water		
	Terpenes	26	5147
	Hydrocarbons, petroleum distillates		
	Alkoxylated alcohols	140	
	Fatty acid derivatives		
35	Hydrocarbons, petroleum distillates		
	Hydrocarbons, aromatic	3	1.1×10^{4}
36	Fatty acid derivatives		
	Hydrocarbons, petroleum distillates	50	8014
	Hydrocarbons, aromatic		
	Propylene glycol ethers	1979	6.4×10^{4}
37	Water		
	Hydrocarbons, petroleum distillates		
	Hydrocarbons, aliphatic		
	Hydrocarbons, aromatic	100	1.5×10^{5}
38	Hydrocarbons, petroleum distillates		
	Alkoxylated alcohols		
	Fatty acid derivatives		
39	Water		
	Hydrocarbons, petroleum distillates	50	5.6×10^{4}
	Propylene glycol ethers	200	8.8×10^{4}
	Alkanolamines	25	
	Ethylene glycol ethers	83	4.5×10^{5}
40	Hydrocarbons, aromatic		
	Hydrocarbons, petroleum distillates	59	8415
	Fatty acid derivatives		
	Ethoxylated nonylphenol	318	

[1] A Margin-of-Exposure (MOE) or a Hazard Quotient (HQ) gives an estimate of the "margin of safety" between an estimated exposure level and the level at which adverse effects may occur. Hazard Quotient values below unity imply that adverse effects are very unlikely to occur. The more the Hazard Quotient exceeds unity, the greater is the level of concern. High MOE values such as values greater that 100 for a NOAEL-based MOE or 1000 for a LOAEL-based MOE imply a low level of concern. As the MOE decreases, the level of concern increases. The hazard values used in the HQ or MOE calculations were taken from Table 2-3. The exposure values used in the calculations were taken from Table 3-2.

[2] The absence of HQ or MOE values in this table indicates that insufficient hazard data were available to calculate a HQ or MOE for that chemical.

Below is a summary of risks found for each formulation. This summary is intended to convey the risks that these formulations may present under typical conditions of use. A summary of the toxicological endpoints associated with chemicals of concern is shown in Table 3-9.

Blanket Wash 1

Worker Risk

Risks for this formulation could not be quantified due to the unavailability of hazard values[d]. However, overall concern is low because of low inhalation exposure levels, poor dermal absorption, and low to moderate toxicologic concern based on structure-activity analysis.

Blanket Wash 3

Worker Risk - Dermal Exposure

Hazard quotient calculations indicate a concern for exposure to some aromatic hydrocarbons and very low concern for exposure to other aromatic hydrocarbons. However, the hazard values are based upon oral or inhalation studies. Margin of exposure calculations indicate concern for exposures to aromatic hydrocarbons. However, the hazard values are based upon inhalation studies. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values.

Worker Risk - Inhalation Exposure

Hazard quotient calculations indicate very low concern for exposure to aromatic hydrocarbons. However, the hazard value for one of these aromatic hydrocarbons is based upon an oral study. The RfD used to calculate the risk estimate is classified as “low confidence” by IRIS (Integrated Risk Information System). Margin of exposure calculations indicate concern for exposure to certain aromatic hydrocarbons, but very low concern for exposure to others. Due to negligible inhalation exposure, the alkyl benzene sulfonates and fatty acid derivatives used in this formulation present no concern. Risks for other chemicals in the formulation could not be quantified due to the unavailability of hazard values.

Blanket Wash 4

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for exposure to terpenes and low concern for exposure to the ethoxylated nonylphenols. However, the hazard value for terpenes is based upon an oral study.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate a very low concern for exposure to terpenes. However, the hazard value is based upon an oral study. Due to negligible exposure, no concern exists for exposure to the ethoxylated nonylphenols.

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[d]Hazard values refer to NOAELs, LOAELs, RfDs, or RfCs used in calculating hazard quotients or margins of exposure or slope factor used in calculating carcinogenic risk. The specific toxicologic endpoints associated with the chemicals of concern are shown in Table 2-3 “Human Health Hazard Summary”

Blanket Wash 5

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for exposures to aromatic hydrocarbons and ethylene glycol ethers, and very low concern for exposure to ethoxylated nonylphenols. However, the hazard value for aromatic hydrocarbons is based upon an inhalation study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate a very low concern for exposure to aromatic hydrocarbons and ethylene glycol ethers. Due to negligible exposure, no concern exists for the other chemicals in this formulation.

Blanket Wash 6

Worker Risk - Dermal Exposure

Margins of exposure calculations indicate concern for exposure to petroleum distillate hydrocarbons. However, the hazard value is based upon inhalation studies. Risks for other chemicals in the formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons because of the possible presence of carcinogenic compounds. The fatty acid derivatives and alkyl benzene sulfonates are of low concern because of their expected low rate of dermal absorption and low to moderate hazard.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for exposure to petroleum distillate hydrocarbons. Due to low or negligible inhalation exposures, the petroleum distillate hydrocarbons, alkyl benzene sulfonates, and fatty acid derivatives used in this formulation present little or no concern.

Blanket Wash 7

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for exposure to terpenes and very low concern for exposure to ethoxylated nonylphenol. However, the hazard value for terpenes is based upon an oral study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values, although none of the chemicals present more than a low to moderate hazard concern based on structure-activity analysis.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate a very low concern for exposure to terpenes. However, the hazard value is based upon an oral study. Due to low or negligible inhalation exposures, other chemicals in the formulation present little or no concern.

Table 3-9. Occupational Risks Summarized by Formulation

Form. Number	Chemicals of Concern*	Toxicologic Concern**
1	None	
3	Hydrocarbons, aromatic (inhalation and dermal exposures)	kidney effects, urinary tract and enzyme effects, reproductive and developmental effects
4	Terpenes	liver effects
5	Hydrocarbons, aromatic Ethylene glycol ethers	reproductive and developmental effects blood effects
6	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic	blood effects possible presence of carcinogens
7	Terpenes	liver effects
8	Propylene glycol ethers Hydrocarbons, aromatic	blood effects possible presence of carcinogens
9	None	
10	None	
11	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic	blood effects possible presence of carcinogens
12	Hydrocarbons, petroleum distillates	blood effects
14	None	
16	Terpenes	liver effects
17	Fatty acid derivatives	possible concern for diethanolamine component of salt
18	Hydrocarbons, petroleum distillates Dibasic esters	blood effects olfactory effects
19	None	
20	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic	blood effects possible presence of carcinogens
21	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates	reproductive and developmental effects blood effects
22	Hydrocarbons, aromatic	possible presence of carcinogens
23	Terpenes Nitrogen heterocyclics	liver effects developmental effects
24	Alkyl benzene sulfonates Terpenes Ethylene glycol ethers	concern based on MOE from single dose study liver effects blood effects
25	Terpenes Esters/lactones	liver effects developmental effects
26	Esters/lactones	developmental effects

Form. Number	Chemicals of Concern*	Toxicologic Concern**
27	Terpenes	liver effects
28	Hydrocarbons, petroleum distillates	blood effects
29	None	
30	Hydrocarbons, aromatic	reproductive and developmental effects
31	Hydrocarbons, aromatic	reproductive and developmental effects
32	Insufficient data for evaluation	
33	Hydrocarbons, aromatic Hydrocarbons, petroleum distillates	reproductive and developmental effects blood effects
34	Terpenes	liver effects
35	Hydrocarbons, aromatic	reproductive and developmental effects
36	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic	blood effects possible presence of carcinogens
37	Hydrocarbons, aromatic	reproductive and developmental effects
38	Insufficient data for evaluation	
39	Hydrocarbons, petroleum distillates Propylene glycol ethers Ethylene glycol ethers Alkanolamines	blood effects blood effects blood effects blood effects
40	Hydrocarbons, petroleum distillates Hydrocarbons, aromatic	blood effects possible presence of carcinogens

* Table lists only chemicals that triggered concern. Formulations may also include other chemicals. All concerns are for dermal exposures only unless otherwise specified. Identification of chemicals of concern is based on Hazard Quotient and Margin-of-Exposure estimates shown in Table 3-8. The Hazard Quotient and Margin-of-Exposure estimates do not necessarily apply to all of the toxicologic endpoints listed in this table. Hazard Quotient and Margin-of-Exposure calculations are usually based on a "NOAEL" or the "LOAEL" for the most sensitive endpoint.

** The "Toxicologic Concern" column lists adverse effects that have been reported in the literature for animal or human studies. This is simply a qualitative listing of reported effects and does not imply anything about the severity of the effects nor the doses at which the effects occur. Furthermore, an entry in this column does not necessarily imply that EPA has reviewed the reported studies or that EPA concurs with the authors' conclusions. Toxicologic concerns are described as follows:

blood effects = hematological effects, i.e., adverse effects on blood cells
carcinogens = possible cancer causing agents
developmental effects = adverse effects on the developing embryo, fetus, or newborn
kidney effects = adverse effects on kidney physiology
liver effects = adverse effects on liver physiology
olfactory effects = adverse effects on nasal physiology
reproductive effects = adverse effects on the ability of either males or females to reproduce
"none" = no concern at predicted exposure levels

Blanket Wash 8

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate low concern for propylene glycol ethers and very low concern for ethoxylated nonylphenol. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons because of the possible presence of carcinogenic compounds. The other compounds in the formulation present low to moderate hazard concerns.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for propylene glycol ethers. However, the hazard value is based upon a subacute oral study. Due to low or negligible inhalation exposures, other chemicals in the formulation present little or no concern.

Blanket Wash 9

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate a very low concern for ethoxylated nonylphenol. Risks for the fatty acid derivative could not be quantified but is expected to be very low based on structure-activity predictions of low toxicity and poor dermal absorption.

Worker Risk - Inhalation Exposure

Due to negligible inhalation exposure, the chemicals used in this formulation present no concern.

Blanket Wash 10

Worker Risk - Dermal Exposure

Risk for this formulation could not be quantified but is expected to be very low based on structure-activity predictions of low toxicity and poor dermal absorption of the fatty acid derivatives.

Worker Risk - Inhalation Exposure

Due to negligible exposure, the fatty acid derivatives used in this formulation present no concern.

Blanket Wash 11

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for exposure to petroleum distillate hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for the other chemicals in this formulation could not be quantified due to the unavailability of hazard values.

Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons because of the possible presence of carcinogenic compounds. The alkyl benzene sulfonates are of low concern because of their expected low rate of dermal absorption and low to moderate hazard.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for exposure to petroleum distillate hydrocarbons. Due to low or negligible inhalation exposures, other chemicals in the formulation present little or no concern.

<u>Blanket Wash 12</u>

Worker Risks - Dermal Exposure

Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons. However the hazard value is based upon an inhalation study. Risk could not be quantified but structure-activity analysis indicates a low to moderate hazard concern.

Worker Risks - Inhalation Exposure

Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons. Risk could not be quantified but is expected to be low because of low exposure and low to moderate toxicity.

<u>Blanket Wash 14</u>

Worker Risks - Dermal Exposure

Risks for this formulation could not be quantified but are expected to be low because of structure-activity predictions of low toxicity for both the fatty acid derivatives and the propylene glycol ethers. Also, the fatty acid derivatives are expected to be poorly absorbed.

Worker Risks - Inhalation Exposure

Due to negligible exposure, the fatty acid derivatives used in this formulation present no concern. Risks for the propylene glycol ether are also expected to be low because of low exposure and its predicted low toxicity.

<u>Blanket Wash 16</u>

Worker Risks - Dermal Exposure

Margin of exposure calculations indicate concern for exposure to terpenes. However, the hazard value is based upon an oral study. Risks for the other chemicals in this formulation could not be quantified due the unavailability of hazard values. Structure-activity analyses of these compounds indicates low to moderate hazard concerns.

Worker Risks - Inhalation Exposure

Margin of exposure calculations indicate very low concern for exposure to terpenes. However, the hazard value for terpenes is based upon an oral study. Risks for the other chemicals in this formulation could not be quantified but are expected to be low because of low exposures and low to moderate toxicity.

Blanket Wash 17

Worker Risks - Dermal Exposure

Hazard quotient calculations indicate very low concern for propylene glycol ethers. However, the hazard value is based upon an oral study. Margin of exposure calculations indicate very low concern for ethoxylated nonylphenol and alkali/salts. However, the hazard value for alkali salts is based upon oral values. The alkanolamine component of the fatty acid derivative/alkanolamine salt presents a possible concern. However, dermal absorption of the alkanolamine salt is likely to be lower than that of free alkanolamine.

Worker Risks - Inhalation Exposure

Hazard quotient calculations indicate no concern for glycols. However, the hazard value is based upon an oral study. Due to negligible inhalation exposure, ethoxylated nonylphenol, fatty acid derivatives and alkali/salts present very low concern.

Blanket Wash 18

Worker Risks - Dermal Exposure

Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons and dibasic esters. However, the hazard values are based on inhalation studies. Risk from the alkyl benzene sulfonates could not be quantified but is expected to be low because of structure-activity predictions of poor absorption and low to moderate toxicity. Risk from esters/lactones is also expected to be low based on structure-activity predictions of low toxicity.

Worker Risks - Inhalation Exposure

Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons and dibasic esters. Risks for other chemicals in this formulation could not be quantified but are expected to be low due to low or negligible exposures and low to moderate hazard concerns.

Blanket Wash 19

Worker Risk - Dermal Exposure

Risks for this formulation could not be calculated due to the unavailability of hazard values. However, risks are expected to be low based on structure-activity predictions of low toxicity of propylene glycol ethers and poor absorption and low to moderate toxicity of the fatty acid derivatives.

Worker Risk - Inhalation Exposure

Due to negligible exposure, the fatty acid derivatives present no concern. Risks for propylene glycol ethers are expected to be low because of low exposure and low hazard concern.

Blanket Wash 20

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for the other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Risk from the alkyl benzene sulfonates is expected to be low because of structure-activity predictions of poor absorption and low to moderate toxicity. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons because of the possible presence of carcinogenic compounds.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons. Risks for other chemicals in this formulation could not be quantified but are expected to be low due to low or negligible exposures and low to moderate hazard concerns.

Blanket Wash 21

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for aromatic hydrocarbons and petroleum distillate hydrocarbons. However, the hazard values are based upon inhalation studies. Risk for the fatty acid derivatives could not be quantified but are expected to be low based on structure-activity predictions of poor absorption and low toxicity.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for aromatic hydrocarbons and petroleum distillate hydrocarbons. Due to negligible exposure and predicted low toxicity and absorption, fatty acid derivatives presents no concern.

Blanket Wash 22

Worker Risk - Dermal Exposure

Risks for this formulation could not be calculated due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons because of the possible presence of carcinogenic compounds. Risks from the fatty acid derivatives are expected to be low based on structure-activity predictions of poor absorption and low to moderate toxicity.

Worker Risk - Inhalation Exposure

Risks could not be quantified but are expected to be low due to low or negligible exposures.

Blanket Wash 23

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate possible concerns for terpenes and nitrogen heterocyclics. However, the hazard value for terpenes is based upon an oral study. Risks for the alkoxylated alcohols could not be quantified but are expected to be low based on structure-activity predictions of poor absorption and low to moderate toxicity.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for terpenes and nitrogen heterocyclics. However, the hazard value for terpenes is based upon an oral study. Risks for the alkoxylated alcohols could not be quantified but are expected to be low based on low exposure and structure-activity predictions of poor absorption and low to moderate toxicity.

Blanket Wash 24

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for alkyl benzene sulfonates and terpenes, possible concern for ethylene glycol ethers, and very low concern for ethoxylated nonylphenol. However, the hazard value for terpenes is based upon an oral study. Risks for alkali/salts could not be quantified but are expected to be very low based on structure-activity predictions of no absorption and low to moderate toxicity.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for terpenes and ethylene glycol ethers. However, the hazard value for terpenes is based upon an oral study. Due to negligible exposure, the other chemicals in this formulation present no concern.

Blanket Wash 25

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for exposure to terpenes and possible concern for exposure to esters/lactones. However, the hazard values are based upon oral studies. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. The other chemicals are all terpene-type compounds and are rated as low to moderate hazard concern based on structure-activity analysis.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for exposure to terpenes and esters/lactones. However, the hazard values are based upon oral studies. Risks for other chemicals in this formulation could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

Blanket Wash 26

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for esters/lactones, and very low concern for the fatty acid derivatives. However, the hazard values are based upon oral studies. Risks for the fatty acid derivatives could not be quantified but are expected to be low because of structure-activity predictions of poor absorption and low toxicity.

Worker Risk - Inhalation Exposure

Due to negligible exposure, the chemicals used in this formulation present no concern.

Blanket Wash 27

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for terpenes. However, the hazard value is based upon an oral study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. The other chemicals are all terpene-type compounds and are rated as low to moderate hazard concern based on structure-activity analysis.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for terpenes. However, the hazard value is based upon an oral study. Risks for other chemicals in this formulation could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

Blanket Wash 28

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons. However, the hazard value is based upon an inhalation study.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate low concern for petroleum distillate hydrocarbons.

Blanket Wash 29

Worker Risk - Dermal Exposure

Risks for this formulation could not be quantified but are expected to be low because of structure-activity predictions of poor absorption and low toxicity for the fatty acid derivatives.

Worker Risk - Inhalation Exposure

Due to negligible exposure, the chemicals in this formulation present no concern.

Blanket Wash 30

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for aromatic hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for propylene glycol ethers could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low hazard concern for propylene glycol ethers.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for aromatic hydrocarbons. Risks for propylene glycol ethers could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low toxicity.

Blanket Wash 31

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for exposure to aromatic hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for petroleum distillate hydrocarbons could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low to moderate hazard concern for petroleum distillate hydrocarbons.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for exposure to aromatic hydrocarbons. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

Blanket Wash 32

Worker Risk

Risks for this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low to moderate hazard concern for petroleum distillate hydrocarbons.

Blanket Wash 33

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons and aromatic hydrocarbons, and very low concerns for propylene glycol ethers. However, the hazard values for petroleum distillate hydrocarbons and aromatic hydrocarbons are based upon an inhalation study.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons, aromatic hydrocarbons, and propylene glycol ethers.

Blanket Wash 34

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concerns for terpenes and very low concerns for the fatty acid derivatives. However, the hazard values are based upon oral studies. Risks for fatty acid derivatives could not be quantified but are expected to be low because of structure-activity predictions of poor absorption and low to moderate toxicity. Risks for petroleum distillate hydrocarbons could not be quantified. Structure-activity analysis indicates low to moderate hazard concern for these chemicals.

Worker Risk - Inhalation Exposure

Margin of exposure values indicate very low concern for terpenes. However, the hazard value is based upon an oral study. Due to negligible exposure, the fatty acid derivatives present no concern. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low because of low exposure and structure-activity predictions of low to moderate hazard concern.

Blanket Wash 35

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for aromatic hydrocarbons. However, the hazard value is based upon an inhalation study. Risks for petroleum distillate hydrocarbons could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates low to moderate hazard concern for petroleum distillate hydrocarbons.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for aromatic hydrocarbons. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low based on low exposure and structure-activity predictions of low to moderate toxicity.

<u>Blanket Wash 36</u>

Worker Risk - Dermal Exposure

Margin of exposure calculation indicate concern for petroleum distillate hydrocarbons, and very low concern for propylene glycol ethers. However, the hazard value for petroleum distillate hydrocarbons is based upon an inhalation study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons because of the possible presence of carcinogenic compounds. Risks from fatty acid derivatives are expected to be low because of structure-activity predictions of poor absorption and low toxicity.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons and propylene glycol ethers. Due to negligible exposure, the fatty acid derivatives present no concern. Risks from aromatic hydrocarbons could not be quantified but are expected to be low because of low exposure.

<u>Blanket Wash 37</u>

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate possible concern for aromatic hydrocarbons. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. The petroleum distillate hydrocarbons are considered to present low to moderate hazard concerns according to structure-activity analysis.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for aromatic hydrocarbons. Risks for other chemicals in this formulation could not be quantified but are expected to be low because of low exposure and structure-activity predictions of low to moderate hazard.

<u>Blanket Wash 38</u>

Worker Risk - Dermal Exposure

Risks for this formulation could not be quantified due to the unavailability of hazard values. The fatty acid derivatives and alkoxylated alcohols are expected to present low risk because of structure-activity predictions of poor absorption and low or low to moderate toxicity. Petroleum distillate hydrocarbons present low to moderate hazard concern according to structure-activity analysis.

Worker Risk - Inhalation Exposure

Due to negligible exposure, the fatty acid derivatives present no concern. Risks for petroleum distillate hydrocarbons could not be quantified but are expected to be low because of low exposure and structure-activity predictions of low to moderate toxicity.

Blanket Wash 39

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons, ethylene glycol ethers, and alkanolamines, and possible concerns for propylene glycol ethers. However, the hazard value for petroleum distillate hydrocarbons is based on an inhalation study.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons, propylene glycol ethers, and ethylene glycol ethers. However, the hazard value used for propylene glycol ethers is based on an oral study. Due to negligible exposure, alkanolamines present no concern.

Blanket Wash 40

Worker Risk - Dermal Exposure

Margin of exposure calculations indicate concern for petroleum distillate hydrocarbons and very low concern for ethoxylated nonylphenol. However, the hazard value for petroleum distillate hydrocarbons is based upon an inhalation study. Risks for other chemicals in this formulation could not be quantified due to the unavailability of hazard values. Structure-activity analysis indicates a moderate hazard concern for aromatic hydrocarbons because of the possible presence of carcinogenic compounds. Risks from fatty acid derivatives are expected to be low because of structure-activity predictions of poor absorption and low toxicity.

Worker Risk - Inhalation Exposure

Margin of exposure calculations indicate very low concern for petroleum distillate hydrocarbons. Due to negligible exposure, fatty acid derivatives and ethoxylated nonylphenol present no concern. Risks from aromatic hydrocarbons could not be quantified but are expected to be low because of low exposure.

3.4.4 General Population Risks

No concerns were identified for general population exposures through drinking water, fish ingestion, or ambient air as seen in Table 3-10. Predicted exposure levels in these environmental media were extremely low. The calculated risk numbers should be viewed as low-confidence estimates because of the many uncertainties associated with both the hazard and exposure components of the calculation. However, the overall risk conclusion can be regarded with high confidence because all of the risk estimates fall far below standard risk benchmarks. Thus, the “true” risk value could vary substantially from the estimated value without changing the conclusion. In addition, a generally conservative approach (i.e. one that overestimates the risk) was taken in the assessment.

A Margin-of-Exposure (MOE) or a Hazard Quotient (HQ) gives an estimate of the "margin of safety" between an estimated exposure level and the level at which adverse effects may occur. Hazard Quotient values below unity imply that adverse effects are very unlikely to occur. The more the Hazard Quotient exceeds unity, the greater is the level of concern. High MOE values such as values greater than 100 for a NOAEL-based MOE or 100 for a LOAEL-based MOE imply a low level of concern. As the MOE decreases, the level of concern increases. The hazard values used in the HQ or MOE calculations were taken from Table 2-3. The exposure values used in the calculations were taken from Table 3-4. The absence of HQ or MOE values in this table indicates that insufficient hazard data were available to calculate a HQ or MOE for that chemical.

Table 3-10. General Population Risk Estimates for Drinking Water, Fish Ingestion, and Inhalation

Form. Number	Chemical Components	Drinking Water MOE[1,2]	Fish Ingestion MOE[1,2]	Inhalation MOE[1,2]
1	Fatty acid derivatives			
	Alkoxylated alcohols			
3	Hydrocarbons, petroleum distillates			
	Fatty acid derivatives			
	Hydrocarbons, aromatic			1.6×10^5
	Hydrocarbons, aromatic			2.0×10^4
	Hydrocarbons, aromatic			3.0×10^{-5} (HQ)
	Hydrocarbons, aromatic			7.1×10^{-5} (HQ)
	Alkyl benzene sulfonates			
4	Terpenes			8.0×10^4
	Ethoxylated nonylphenol[3]	8.8×10^5		
5	Water			
	Hydrocarbons, aromatic			1.2×10^5
	Ethylene glycol ethers			4.5×10^4
	Ethoxylated nonylphenol[3]	7×10^6		
	Alkyl benzene sulfonates			
	Alkoxylated alcohols			
	Alkyl benzene sulfonates			
	Alkali/salts			
6	Fatty acid derivatives			
	Hydrocarbons, petroleum distillates			6.0×10^5
	Hydrocarbons, aromatic			
	Alkyl benzene sulfonates			
7	Terpenes			
	Terpenes			3.0×10^5
	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			
	Ethoxylated nonylphenol[3]	2.3×10^7		
	Alkoxylated alcohols			

Form. Number	Chemical Components	Drinking Water MOE[1,2]	Fish Ingestion MOE[1,2]	Inhalation MOE[1,2]
8	Water			
	Hydrocarbons, aromatic			
	Propylene glycol ethers			7.0×10^{5}
	Alkyl benzene sulfonates	5.0×10^{7}		
	Ethoxylated nonylphenol[3]	8.1×10^{6}		
	Alkyl benzene sulfonates			
	Alkoxylated alcohols			
	Alkyl benzene sulfonates			
	Alkali/salts			
9	Fatty acid derivatives			
	Water			
	Ethoxylated nonylphenol[3]	2.3×10^{7}		
10	Fatty acid derivatives			
	Water			
11	Fatty acid derivatives			
	Hydrocarbons, petroleum distillates			4.0×10^{5}
	Hydrocarbons, aromatic			
	Alkyl benzene sulfonates			
12	Hydrocarbons, petroleum distillates			
	Hydrocarbons, petroleum distillates			2.0×10^{6}
	Water			
14	Fatty acid derivatives			
	Propylene glycol ethers			
	Water			
16	Terpenes			3.0×10^{5}
	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			
17	Ethoxylated nonylphenol[3]	3.2×10^{7}		
	Glycols			1.0×10^{-5} (HQ)
	Fatty acid derivatives			
	Alkali/salts			
	Water			

Form. Number	Chemical Components	Drinking Water MOE[1,2]	Fish Ingestion MOE[1,2]	Inhalation MOE[1,2]
18	Fatty acid derivatives			
	Hydrocarbons, petroleum distillates			4.0×10^5
	Hydrocarbons, aromatic			
	Dibasic esters			3.0×10^4
	Dibasic esters			3.0×10^4
	Dibasic esters			3.0×10^4
	Esters/lactones			
	Alkyl benzene sulfonates			
19	Fatty acid derivatives			
	Propylene glycol ethers			
	Water			
20	Water			
	Hydrocarbons, petroleum distillates			8.0×10^5
	Hydrocarbons, aromatic			
	Alkyl benzene sulfonates			
21	Hydrocarbons, aromatic			2.5×10^5
	Hydrocarbons, petroleum distillates			1.0×10^5
	Fatty acid derivatives			
22	Fatty acid derivatives			
	Hydrocarbons, aromatic			
	Water			
23	Terpenes			1.0×10^5
	Nitrogen heterocyclics			1.0×10^4
	Alkoxylated alcohols			
	Water			
24	Terpenes			4.0×10^5
	Ethylene glycol ethers			1.1×10^4
	Ethoxylated nonylphenol[3]	1.5×10^7		
	Alkyl benzene sulfonates	5.0×10^6		
	Alkali/salts			
	Water			
25	Terpenes			
	Terpenes			3.0×10^5
	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			
	Esters/lactones			2.0×10^6

Form. Number	Chemical Components	Drinking Water MOE[1,2]	Fish Ingestion MOE[1,2]	Inhalation MOE[1,2]
26	Fatty acid derivatives			
	Esters/lactones			
	Fatty acid derivatives	1.3×10^{8}	6.3×10^{5}	
	Esters/lactones			
27	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			
	Terpenes			6.0×10^{5}
	Terpenes			
	Terpenes			
28	Hydrocarbons, petroleum distillates			$1.2 \text{ x } 10^{5}$
29	Fatty acid derivatives			
30	Hydrocarbons, aromatic			7.0×10^{4}
	Propylene glycol ethers			
	Water			
31	Hydrocarbons, aromatic			2.5×10^{5}
	Hydrocarbons, petroleum distillates			
32	Hydrocarbons, petroleum distillates			
33	Hydrocarbons, petroleum distillates			2.0×10^{5}
	Hydrocarbons, aromatic			1.6×10^{5}
	Propylene glycol ethers			1.0×10^{6}
	Water			
34	Water			
	Terpenes			4.0×10^{5}
	Hydrocarbons, petroleum distillates			
	Alkoxylated alcohols	6.0×10^{7}		
	Fatty acid derivatives			
35	Hydrocarbons, petroleum distillates			
	Hydrocarbons, aromatic			3.0×10^{4}
36	Fatty acid derivatives			
	Hydrocarbons, petroleum distillates			8.0×10^{5}
	Hydrocarbons, aromatic			
	Propylene glycol ethers			2.0×10^{6}
37	D. I. Water			
	Hydrocarbons, petroleum distillates			
	Hydrocarbons, aliphatic			
	Hydrocarbons, aromatic			1.2×10^{5}

Form. Number	Chemical Components	Drinking Water MOE[1,2]	Fish Ingestion MOE[1,2]	Inhalation MOE[1,2]
38	Hydrocarbons, petroleum distillates			
	Alkoxylated alcohols			
	Fatty acid derivatives			
39	Water			
	Hydrocarbons, petroleum distillates			8.0×10^5
	Propylene glycol ethers			1.0×10^6
	Alkanolamines	4.0×10^6		
	Ethylene glycol ethers			1.1×10^5
40	Hydrocarbons, aromatic			
	Hydrocarbons, petroleum distillates			8.0×10^5
	Fatty acid derivatives			
	Ethoxylated nonylphenol[3]	1.6×10^7		

[1] A Margin-of-Exposure (MOE) or a Hazard Quotient (HQ) gives an estimate of the "margin of safety" between an estimated exposure level and the level at which adverse effects may occur. Hazard Quotient values below unity imply that adverse effects are very unlikely to occur. The more the Hazard Quotient exceeds unity, the greater is the level of concern. High MOE values such as values greater that 100 for a NOAEL-based MOE or 100 for a LOAEL-based MOE imply a low level of concern. As the MOE decreases, the level of concern increases. The hazard values used in the HQ or MOE calculations were taken from Table 2-3. The exposure values used in the calculations were taken from Tables 3-4 and 3-5.

[2] The absence of HQ or MOE values in this table indicates no exposure is expected by this route or that insufficient hazard data were available to calculate a HQ or MOE for that chemical.

[3] Based on testing data (Weeks, A.J. et al. 1996. *Proceedings of the CESIO 4th World Surfactants Congress, Barcelona, Spain*. Brussels, Belgium: European Committee on Surfactants and Detergents, pp. 276-291.) the original estimate of POTW removal has been changed from 100% reported in the draft document to 95% in the final report. This revision results in increased estimates of releases to surface water. When the releases to surface water are compared with the concern concentration set at the default value of 0.001 mg/L, the formulations containing ethoxylated nonylphenols (formulations 4, 5, 7, 8, 9, 17, 24 and 40) present concerns to aquatic species that were not reported in the draft CTSA.

3.5 PROCESS SAFETY CONCERNS

Exposure to chemicals is just one of the safety issues that printers may have to deal with during their daily activities. Preventing worker injuries should be a primary concern for employers and employees alike. Work-related injuries may result from faulty equipment, improper use of equipment or bypassing equipment safety features, failure to use personal protective equipment, and physical stresses that may appear gradually as a result of repetitive motions (i.e., ergonomic stresses). Any or all of these types of injuries may occur if proper safeguards or practices are not in place and correctly used. The use of personal safety equipment and the presence of safety guards on equipment can have a substantial impact on business, not only in terms of direct worker safety, but also in reduced operating costs as a result of fewer days of absenteeism, reduced accidents and injuries, and lower insurance costs. Maintaining a safe and efficient workplace requires that employers and employees understand the importance of using personal protective equipment, have appropriate safeguards on mechanical and electrical equipment, store and use chemicals properly, and practice good ergonomic procedures when engaged in physical activity.

Training

A critical element of workplace safety is a well-educated workforce. To help achieve this goal, the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard requires that all employees at printing facilities (regardless of the size of the printing plant) be trained in the use of hazardous chemicals to which they are exposed, therefore, it is recommended that a formal training program be instituted for all workers at lithography plants. Training may be conducted by either facility staff or outside parties who are familiar with the lithography process and the pertinent safety concerns. The training should be held for each new employee, as well as periodic retraining sessions when necessary (for example, if new equipment is to be used), or on a regular schedule. The training program should explain to the workers the types of chemicals with which they work and precautions to be used when handling or storing them; when and how personal protection equipment should be worn; the need for other safety features such as machine guards and their proper use; and how to maintain equipment in good operating condition.

Storing and Using Chemicals Properly

Because lithographic printing requires exposure to and use of a variety of chemicals, it is important that workers know and follow the correct procedures for using and storing the chemicals. Much of the use, disposal, and storage information about blanket wash chemicals may be obtained from the Material Safety Data Sheets provided by the manufacturer for each chemical or formulation. MSDSs will also alert the workers to the need for appropriate personal protection equipment. All chemicals should be stored in appropriate storage space and should be labeled accordingly with all federal, state, and local regulations. Chemicals that are incompatible with other chemicals or that require special precautions in their use should also be appropriately labeled and stored. Because many of the chemicals used in blanket wash formulations are highly flammable, it is recommended that the facility be periodically inspected by the local fire marshall to ensure that the chemicals are stored properly and ventilated, thus reducing the potential for a fire.

Rags or towels that are used to wipe up chemicals or clean blankets may be considered hazardous waste by EPA and state and local agencies if they contain specified hazardous chemicals in sufficient amounts. These towels should be stored and disposed of in accordance with the federal, state, and local regulations. Blanket wash workers should also be aware of the potential for smoldering of the rags, particularly those that contain terpenes. If a printer is uncertain about whether or not the used rags or towels require special treatment as hazardous waste, he or she should contact their local state environmental agency, or state technical assistance program. For further information about the specific safety factors and hazards associated with specific chemicals used in lithography blanket wash formulations, such as flammability and corrosivity, see Section 2.2 Chemical Information.

Use of Personal Safety Equipment

Although EPA developed the Design for the Environment Program to assist industry in determining the environmental effects and risks associated with various industries, worker safety is the responsibility of OSHA. Many printers are already familiar with OSHA's Hazard Communication Standard which covers many aspects of worker safety for a variety of industries, including printing facilities. OSHA has already developed several personal protective equipment standards that are applicable to the printing industry. These standards address general safety requirements (29 CFR Part 1910.132), the use of eye and face protection (Part 1910.133), head protection (Part 1910.135), foot protection (Part 1910.136), and hand protection (Part 1910.138). The standards for eye, face and hand protection are particularly important for the printing industry where there is frequent contact with a variety of chemicals, such as solvents, dispersants, surfactants, and inks, that may irritate or otherwise harm the skin and eyes. In order to prevent or minimize exposure to such chemicals, workers should be trained in the proper use of personal safety equipment. For many blanket wash chemicals, appropriate protective equipment includes goggles to prevent chemical from splashing into the eyes during the transfer of chemicals from large containers to small ones, aprons or other impervious clothing to prevent splashing of chemicals on clothing, and gloves. In some printing facilities with loud presses, hearing protection may be required or recommended.

Other personal safety considerations are the responsibility of the worker. Workers should be discouraged from eating or keeping food near presses or chemicals. Because presses contain moving parts, workers should also be prohibited from wearing jewelry or loose clothing, such as ties, that may become caught in the machinery and cause injury to the worker or the machinery itself. In particular, the wearing of rings or necklaces may lead to injury. Workers with long hair that may also be caught in the machinery should be required to securely pull their hair back or wear a hair net.

<u>Use of Equipment Safeguards</u>

In addition to the use of proper personal protection equipment for all workers, OSHA has developed safety standards that apply to the actual equipment used in printing facilities. These machine safety guards are described in 29 CFR Part 1910.212 and are applicable to all sectors of the industry, including lithography. Among the safeguards recommended by OSHA that may be used for lithographic printers are barrier guards, two-hand trip devices, and electrical safety devices. Safeguards for the normal operation of press equipment are included in the standards for mechanical power-transmission apparatus (29 CFR Part 1910.219) and include belts, pulleys, flywheels, gears, chains, sprockets, and shafts. The National Printing Equipment and Supply Association has made available copies of the American National Standard for Safety Specifications for Printing Press Drive Controls. These safety recommendations address the design of press drive controls specifically, as well as safety signaling systems for web and sheet-fed printing presses. Printers should be familiar with the safety requirements included in these standards and should contact their local OSHA office or state technical assistance program for assistance in determining how to comply with them.

In addition to normal equipment operation standards, OSHA also has a lockout/tagout standard (29 CFR part 1910.147). This standard is designed to prevent the accidental start-up of electric machinery during cleaning or maintenance operations that apply to the cleaning of blankets as well as other operations. This standard has posed particular problems for lithographers during minor, routine procedures such as cleaning the press which requires frequent stops and small movement of the rollers (inching) which may be accomplished without extensive disassembly of the equipment. For such cases, OSHA has granted an exemption for minor servicing of machinery provided the equipment has other appropriate safeguards, such as a stop/safe/ready button which overrides all other controls and is under the exclusive control of the worker performing the servicing. Such minor servicing of printing presses has been determined to include clearing jams, minor cleaning, lubricating, adjusting operations, plate and blanket changing tasks, paper webbing, and roll changing. Rigid finger guards should also extend across the rolls, above and below the area the be cleaned. Proper training of workers is required under the standard whether lockout/tagout is employed or not. For further information on the applicability of the OSHA lockout/tagout standard to printing operations, contact the local OSHA field office or the Printing Industries of America, Inc.

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